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WIND AND SOIL

By Dr. WILLIAM HERBERT HOBBS

EMERITUS PROFESSOR OF GEOLOGY, UNIVERSITY OF MICHIGAN

WIND has been responsible for the removal of soils, as the recent history of the "dust bowl" abundantly testifies. Far more important, however, is the role that wind has played in the creation and deposition of soils. Probably at least ninety per cent. of the richest soils in the

the mouths of great rivers; but the soils which alone permit of such dense populations were first collected by the wind before their deposition by the rivers. Still other great areas of rich soil, such as those of the Ukraine in southern Russia, the wheat and corn belts of our own



FIG. 1. DUST STORM ADVANCING ON KHARTOUM

"granaries of the world," have been transported and deposited by wind, though to a considerable extent they have been later redeposited by water. The teeming millions of humans in China, British India and Egypt dwell on wind-derived soils. The most concentrated populations live upon deltas at

Middle West, and the Pampas of the Argentine, owe their existence to glaciers, running water and wind; the wind, however, *after* instead of *before* the deposition by the water.

Soils are of necessity finely divided; that is to say, they are in powdery form, produced from coherent rock material



FIG. 2. PEBBLE PAVEMENT
IN THE LIBYAN DESERT OF NORTHEAST AFRICA.

either by some abrasional process or by chemical decomposition. Fine subdivision of a solid is a necessary prerequisite to the solution process, and in the laboratory the chemist accomplishes this with the use of mortar and pestle. The principal natural agents of abrasion are glaciers and wind, each with the aid of rock material used as a tool. It is in deserts that sand driven by the wind is able to abrade exposed rock masses; wind-deposited soils fall into two cate-

gories according as they are glacier derived or are of desert origin.

Water must be present in soils in order that they may supply food to plants, but the percolation of water through soils by dissolving out, or leaching, their soluble ingredients brings about their impoverishment. This loss is in addition to that which is removed by plants. In humid regions, therefore, where much water passes through the soil, nitrates, phosphates and salts of potash must be periodically added in order to make up for the losses by these processes.

All wind-derived soils have come to be known under the general name of *loess*, a word of German origin, meaning loose or open-textured. Due to their pervious structure loess soils take up the water of rains, as does a sponge, to produce a slightly plastic mud.

On the continents of Asia and Africa deposits of loess have been derived from the great deserts which cover vast areas of the interior, whereas in Europe and the Americas loess is mainly of glacial origin before its deposition by the wind.

Desert areas are walled in from the

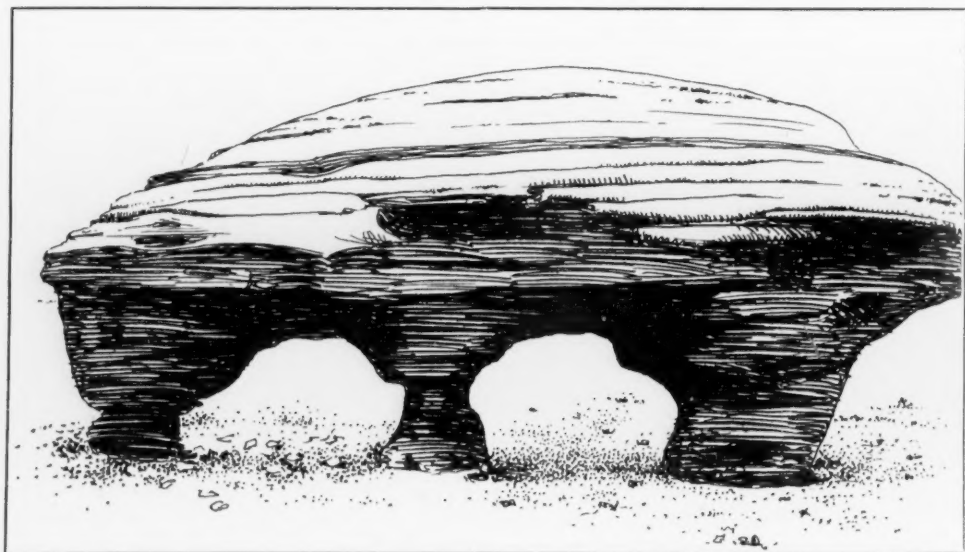


FIG. 3. MUSHROOM ROCK UNDERCUT BY THE DESERT SAND BLAST

prevailing winds by ranges of mountains, at least on the windward side, and it is to this fact that they owe their aridity. The mountains force the moisture-laden winds coming in from the sea to rise and give up their charge of moisture as rain which falls on the outer mountain slopes. In Asia the hinterland is fully walled in on all sides by gigantic mountain systems, but the aridity of the great Libyan desert of Africa is brought about by the Ethiopian Highland and the Red Sea Hills, which cut off the south-east trades from the Indian Ocean. The Sahara desert is due to the Atlas ranges to the north which act in a similar way on winds of the north temperate zone coming in from the northwest. To the south and west the Sahara is without important mountain barriers, but these areas are on the leeward sides of the interior desert from which the soils are transported by the wind.

Although there is a widely prevalent notion that deserts are vast areas of sand, yet the greater part of their surfaces are of hard rock. The heavy sand deposits are largely restricted to the leeward areas that are walled in by mountains. Dunes of sand are also built up far from the borders wherever there are eddied



FIG. 4. ADOBE POST

AT MARKAZ EL SHERIKAH, IN THE LIBYAN DESERT, WHICH HAS BEEN UNDERCUT BY THE SAND BLAST. FIVE YEARS FROM THE TIME THIS PHOTOGRAPH WAS TAKEN IT WAS AGAIN PHOTOGRAPHED AND DISCOVERED TO BE HALF CUT AWAY NEAR ITS BASE.

areas, as on the leeward side of basins of special rock excavation (Fig. 10). The breakdown of the desert rock into dust, sand and larger rock masses is first accomplished mostly through large and sudden changes in temperature between day and night. At midday, under the desert sun, the air temperature may be as high at 150° F. At such times the hand cannot be held on an exposed rock



FIG. 5. ISLAND OF GRANITE NORTH OF KHARTOUM

WITH A DEFINITELY DELIMITED LOWER ZONE, ABOUT A YARD HIGH, POLISHED BY SAND BLAST.

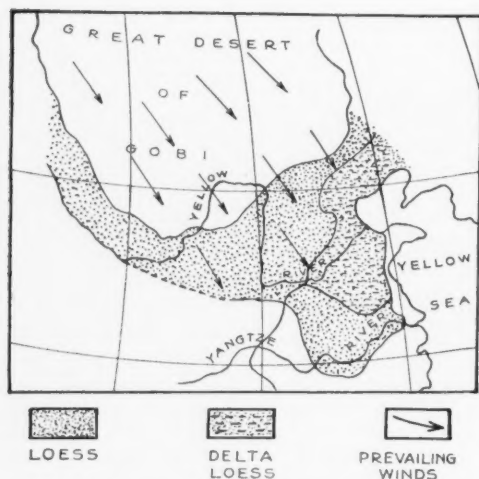


FIG. 6. MAP OF LOESS DEPOSITS

LAI'D DOWN IN CHINA BY NORTHWEST WINDS FROM THE INTERIOR DESERT. MUCH OF THE MATERIAL, YELLOW IN COLOR, WAS GATHERED UP BY THE YELLOW RIVER AND DEPOSITED IN ITS VAST DELTA REGION WHERE IT FLOWS INTO THE YELLOW SEA.

surface, yet night falls suddenly at sunset and one must hurry to get into his blankets, for freezing temperatures may quickly follow. Under these conditions of surface expansion and rapid contraction of the rocks the surface peels or scales off in pieces of pebble size or larger. But more remarkable are the sudden temperature changes when one of the rare and heavy rains occurs. A cloudburst at midday—it is usually at that time—often splits open rock masses several feet in diameter, much as boulders are sometimes broken up by farmers by building a fire on all sides of them and dashing water over them.

The winds which sweep with great violence over deserts pick up the smaller rock scales, and eddies even lift fragments some inches in diameter and drive them hopping along the surface. There are left behind only those rock fragments that are too large to be moved by the wind. Thus is produced the "desert pavement," or "pebble pavement" (Fig. 2). This pavement carries other special names, such as *sérir* in the North African

desert and "gibber plain" in arid Australia.

Coarse sand is carried along near the ground by the hopping motion, or saltation, but the finer sand rises and attacks men mounted upon camels. It is the coarser sand near the ground which accomplishes the principal work of abrasion on the rock of the desert surface. This sand blast process yields the bulk of the dust which is carried out of the desert to form the loess deposit. The desert winds rise suddenly and advance as dust storms with an opaque and terrifying front (Fig. 1).

The effectiveness of sand bombardment during a dust storm is beyond the imagination of one who has not observed it. A tin plate exposed through a sand storm has the tin removed; a bottle simi-



FIG. 7. VERTICAL CLIFFS FORMED OF LOESS ALONG THE YELLOW RIVER.

larly exposed is given a ground glass surface. Iron telegraph poles in North Africa are polished by a single storm to a height of about a yard from the ground, indicating the level to which the saltational movement extends. During an exposure of only a fraction of a year the

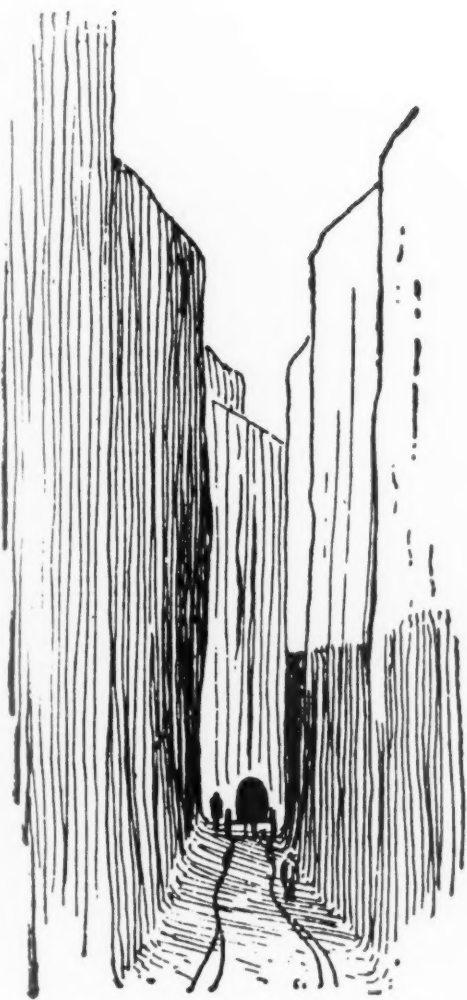


FIG. 8. CANYON IN LOESS OF CHINA.
SUNKEN ROADS CUT BY CENTURIES OF TRAFFIC.

adobe corner of a cemetery within the Great Oasis of the Libyan desert was cut away on the windward side to a depth of six inches a short distance above the ground. But only a yard above the desert surface not even the veneer had been removed (Fig. 4). This sharp falling off of the effectiveness of sand bombardment above the height of a yard or so explains the "mushroom rocks" so common in deserts (Fig. 3).

"Islands" (*Inselberge*) of hard rock which rise above the general level of the

desert floor show polish by the sand blast, and this polish is sharply limited at a height of about a yard (Fig. 5). The sand blast extends much higher, of course, but its effects are produced at a much slower rate.

Wherever marginal mountain barriers exist on the leeward side of deserts, sand is built up in a vast area of dunes on the inner side of the barrier. The mountains themselves have their angular contours rounded off by this veneer, and their valleys and canyons are in part filled by the finely divided loess. The dust, however, is carried out over the mountains to the watered areas outside. For it to be retained where it falls, it is necessary that there be at least a thin grass vegetation. Otherwise, it is again picked up by the next storm wind and is carried farther to leeward. The most extensive, as well as the heaviest, loess deposits in the world are those in China, which were derived from the desert hinterland lying to the northwest beyond the mountains (Fig. 6). In places they have

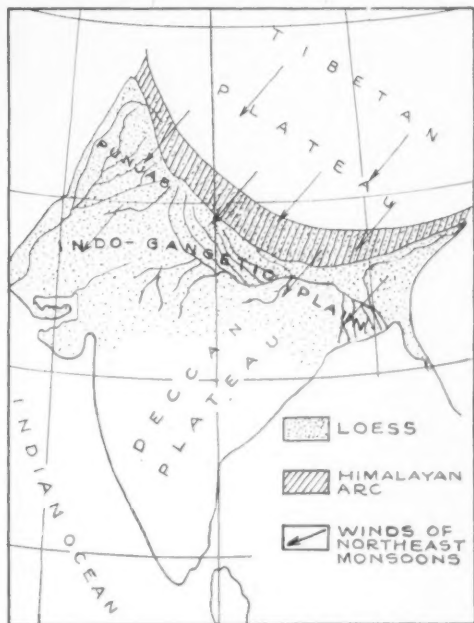


FIG. 9. DEPOSITION OF LOESS
MAP TO SHOW THE DEPOSITS IN BRITISH INDIA.

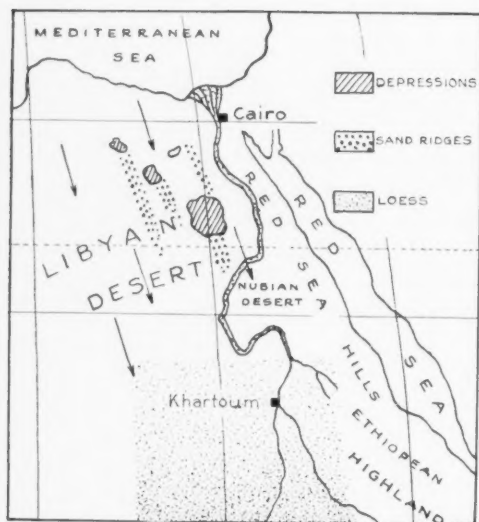


FIG. 10. MAP OF EGYPT AND A PART OF THE ANGLO-EGYPTIAN SUDAN, SHOWING THE PLACE OF ORIGIN OF LOESS SOILS AND THEIR ROUTE OF TRANSFER DOWN THE NILE VALLEY TO THE DELTA WHERE THE RIVER DISCHARGES ITS LOAD INTO THE MEDITERRANEAN SEA.

a thickness as great as 600 feet. Except where it has undergone extensive change from the weather, loess is yellow-brown in color; the marked yellow of the Yellow River and Yellow Sea is explained by the suspended loess.

The yellow color of loess is by no means its only marked characteristic. There are a number of others which are always present, no matter in what country the loess is found or whether it is of desert or of glacial derivation. One of these properties is a vertical parting, or cleaving, habit, which causes the deposit to present vertical cliffs (Fig. 7).

Loess deposits the world over have an internal, fine, tubular structure which permits capillary upward movement of water carrying dissolved salts which restore lime to the surface soil. This structure of loess is explained by the grass blades and roots around which the flying dust became entangled and held. After organic material decomposes, it leaves the vertically directed, porous structure.

Equally characteristic of loess is a firm though weak cementing quality, due to lime, which permits excavations in it of cave-like habitations by local populations. Not only in China, but in almost every loess deposit throughout the world, such habitations are made by the poor. Though a ceiling to a cave holds well so long as it is not disturbed, scratching with the fingernail is sufficient to destroy the cement, and the material thus disintegrated is not again recemented. Whenever the destruction of loess structure occurs where winds prevail, the loess powder is carried off and a hollow results. The traffic of men and animals along roads over thick deposits of loess in the course of centuries gradually transforms these highways into deep canyons (Fig. 8). Though China pre-

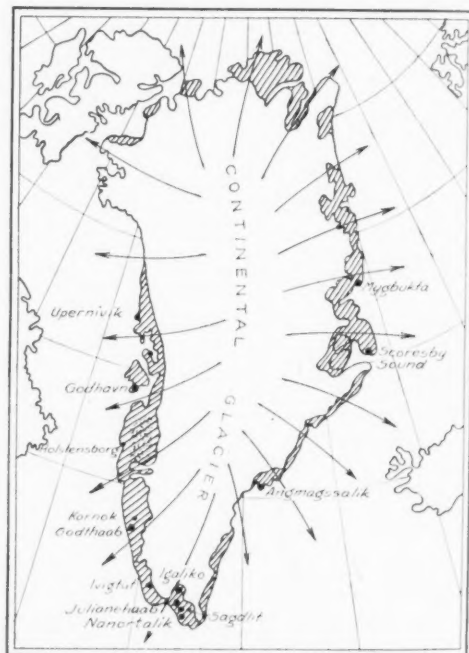


FIG. 11. MAP OF GREENLAND SHOWING THE AREA (800,000 SQUARE MILES) OF THE CONTINENTAL GLACIER (WHITE) AND THE PATTERN OF THE WINDS OF THE GLACIAL ANTICYCLONE (ARROWS). AN AREA OF LOESS DEPOSITS IS SHOWN IN THE SOUTHWEST, EAST OF HOLSTENBORG, WHERE THERE WAS A RESEARCH STATION.

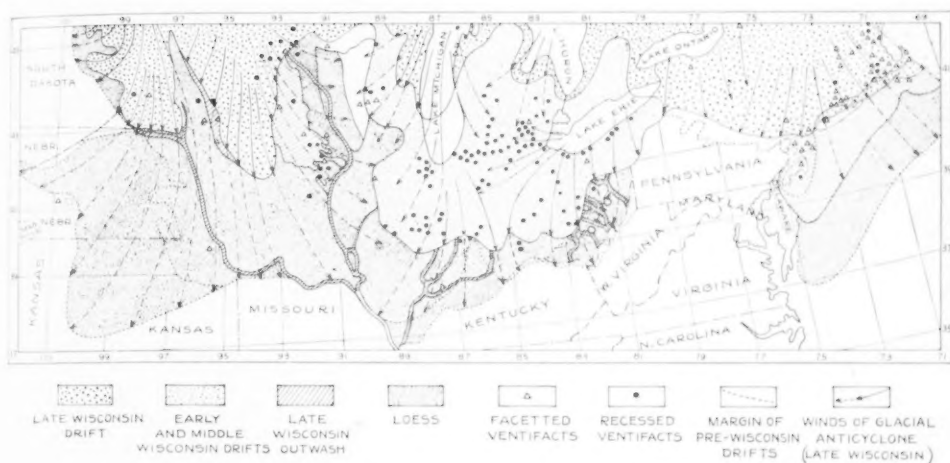


FIG. 12. MAP OF PART OF THE NORTHERN UNITED STATES SHOWING THE AREA WITHIN THE UNITED STATES WHICH WAS COVERED BY THE LATEST PLEISTOCENE CONTINENTAL GLACIER AND THE LOESS DEPOSITS WHICH WERE BUILT UP AROUND ITS BORDERS.

sents the outstanding examples of sunken highways in loess, others of lesser depth are to be seen in all loess deposits wherever there has been a civilization.

Other qualifying marks of loess are lime concretions which are due to the separation out of the lime in the deposits. These concretions assume fantastic figures which have given rise to the names *Loesspuppen* (loess dolls), *Loesskindel* (loess children), and in China, "Stone ginger."

Though no distinct horizontal layers can be made out in loess because of its fine texture, the lime concretions often seem to be in horizontal "banks," as are sometimes other materials. The land origin of these deposits is attested by the enclosure of fossil land snails and bones of vertebrates (mammals), while artifacts betray the evidence of man at the time the deposits were laid down. Loess soils are thus quite generally of Pleistocene (Ice Age) and recent origin.

After China the great granary of Asia is British India, which is separated from the interior desert by the lofty Himalayan Mountain arc. India has a wet season and a dry season. In the former the moisture-laden winds come from the Indian Ocean—the southwest monsoons; the dry season is characterized by dry winds from the desert areas beyond the Himalayas—the northeast monsoons. The latter winds have brought dust from the Tibetan plateau, and this has been spread over the southern slopes of the mountains as well as the plains below. The great rivers Indus and Ganges have gathered up much of this dust and have deposited it as the fine silt of the Indo-Gangetic delta-plain (Fig. 9).

As in China, so also in Hindustan history has been punctuated by almost periodic droughts and consequent crop failures, which resulted in famines and human tragedies surpassing anything elsewhere known. In India the British



FIG. 13. FORMATION OF LOESS DEPOSITS OUTSIDE THE OUTWASH AREA AT THE FRONT OF A CONTINENTAL GLACIER, WHERE IT IS THICKEST.

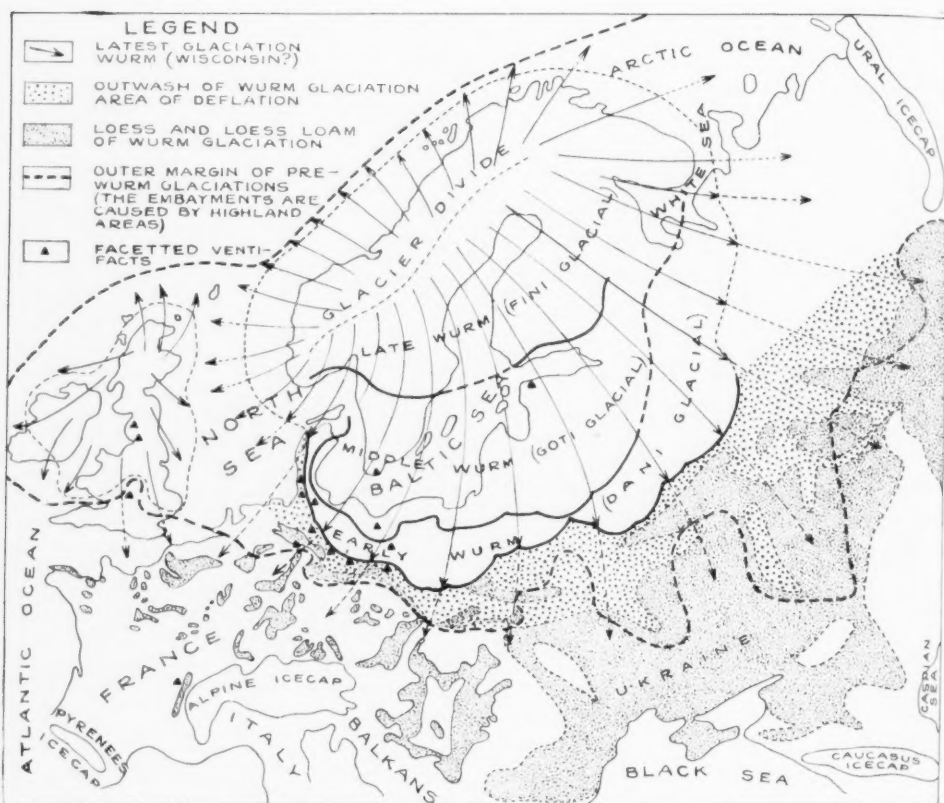


FIG. 14. MAP OF GLACIER-COVERED AREAS IN EUROPE

SHOWING THE BORDER OF THE LATEST PLEISTOCENE CONTINENTAL GLACIER AND THE RICH LOESS LANDS TO THE SOUTH AND EAST, TOGETHER WITH THE EXTENSIVE OUTWASH BELT LYING BETWEEN.

Government has successfully met this menace by irrigation and adequate transportation, and now in that land a great famine is a thing of the past. British India has even been able from its surplus food to supply the great British armies in East and North Africa. The canal irrigation installation of the Punjab, in Northwest India, is now the greatest in the world.

The third granary area of the Eastern Hemisphere, and one which supports a dense population, is Egypt, especially the valley and delta of the River Nile. The fertility of this region is due to the loess soils deposited by winds in the Anglo-Egyptian Sudan, which lies southward within the tropics (Fig. 10). The Libyan and Nubian deserts, through

which the Nile flows as a five-mile wide ribbon of intense fertility, have resulted from the high barrier of the Ethiopian Highland and the Red Sea Hills, which increase in height and merge in the highland to the south. This barrier cuts off the moisture-laden southeast trade winds coming in from the Indian Ocean.

The prevailing winds of the Libyan desert vary only through a few degrees from the direction North 15° West. They blow over a monotonous rock plateau (*Hamada*) which rises several hundred feet above the Nile Valley and is capped by a hard limestone, the Mokattam limestone, on which rests the citadel in Cairo. This resistant limestone is underlain by soft rock beds which, where locally exposed by breaks and ver-

tical displacement, have been excavated by the wind into cliff-bordered depressions. The depressions constitute the oases of the desert, due to the artesian wells through which rises the Nile water from a deeper sandstone layer (Nubian sandstone). In the lee of the depressions long dunes of sand stretch out to the southward for tens of miles. Since there are no mountains to the leeward, the dust carried by the strong north wind is halted only when it meets the first vegetation, which is found about 150 miles to the northward of Khartoum. At this confluence of the White and the Blue Niles is the halting place of the equatorial rains that migrate northward with the sun. The resulting loess deposit is at first thin, but thickens southward (Fig. 10).

To the southward of Khartoum, water is withdrawn from the Blue Nile for the great irrigation installation of the Gezira, the area within the fork of the two Nile branches. These irrigated lands are the cotton plantations of the Sudan. It is to be presumed that loess soils identical with those of the Gezira extend far westward into the unexploited areas of equatorial Africa, since conditions suitable for their formation are indicated. After the war, when exploration and tropical medicine have together accomplished a conquest of that area, another considerable granary may be added to the world's resources.

It has long been known that in addition to the great deposits of loess in Asia

and Africa, there are others in Europe and in the Americas which are clearly not of desert origin. Their distribution is such as to indicate a derivation from former continental glaciers, but just how has not until recently been explained. Two such glaciers are still in existence, one of them on the Antarctic continent, the other over Greenland. The Greenland glacier covers all the land except a relatively narrow ribbon along the coast. Recent studies by the University of Michigan Greenland Expeditions have now shown clearly the manner of formation of the loess, which covers considerable areas within the coastal belt of land. The Greenland, like the Antarctic, glacier is at all times covered by a fixed wind system of centrifugal pattern, which is known as a glacial anticyclone (Fig. 11).

The deposition of the Greenland loess is brought about by seasonal alternation of processes in which running thaw-water and wind play the principal roles within the area extra-marginal to the glacier. The glacier itself has quarried and abraded from its rock bed the material that it has transported, and this material is held in suspension within its bottom layers. On all warmer days during the brief summer season the glacier thaws on its exposed upper surface near its front, and the melt-water descends to the rock bed through the glacier cracks (crevasses). On the bed the water melts its way out and issues beneath the glacier front, carrying a burden of rock material

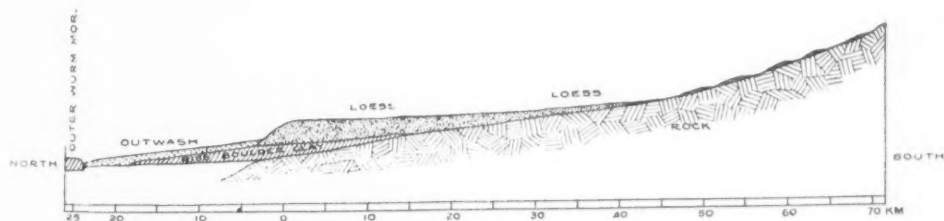


FIG. 15. PROFILE ACROSS OUTWASH AND LOESS DEPOSITS ALONG A NORTH-SOUTH LINE FROM RIESE TO AUE, IN SAXONY. (BASED ON A PROFILE BY GRAHMANN).

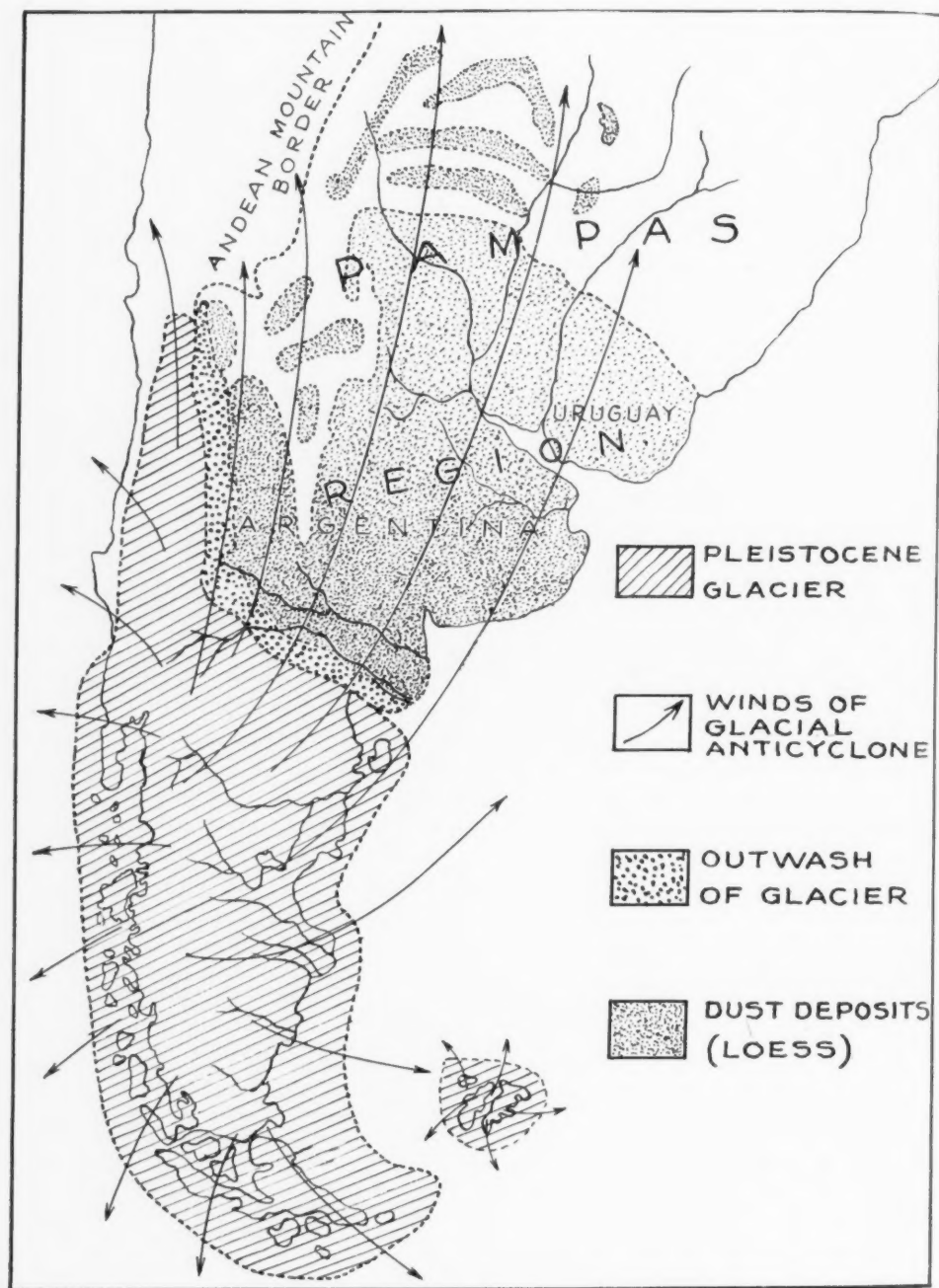


FIG. 16. MAP SHOWING LOESS DEPOSIT AREAS OF THE ARGENTINE IN THEIR RELATION TO THAT OF THE PLEISTOCENE GLACIER FROM WHICH THE LOESS WAS DERIVED.

which varies in coarseness from the finest silt due to abrasion up to boulders several feet in diameter. By the system of "braided" thaw-water channels, that issue from the glacier front and which on exceptionally warm days are joined to a broad flood, the rock debris is sorted and deposited as it builds up an outwash plain of gravel, sand and silt with enclosed boulders.

At the end of the summer all melting of the glacier is brought to an end for the season, the outwash plain then quickly dries out, and the winds of the glacial anticyclone now take over from the thaw-water the work of transportation and redeposition. The sand and the smaller pebbles are lifted and redeposited in irregular hills and dunes, while the silt exists as dust carried higher and farther from the ice front. This dust is carried outward and deposited as loess as soon as it encounters a grass vegetation which as tundra begins at the outer edge of the outwash plain. This is because the summer glacio-fluvial floods completely inhibit the growth of vegetation over the outwash plain. Loess deposits are thickest next to the outwash area and thin outward (Fig. 13).

During the winter the outwash plain has a protective armor of coarse pebbles which is in no way different from the "pebble pavement" of deserts (Fig. 2). In the next succeeding summer season the thaw-water takes over from the wind the work of transportation and further builds up the outwash plain, only to be again deflated by the wind during the succeeding winter. It should be noted that an outwash plain built up by water that issues from the glacier is a prime essential for the formation of the loess deposit by the wind, and that where the water issues at a level above the bottom layers of the glacier, in which alone the rock debris is available, no loess is laid down. It is also to be noted that the loess deposit is thickest near its source, the

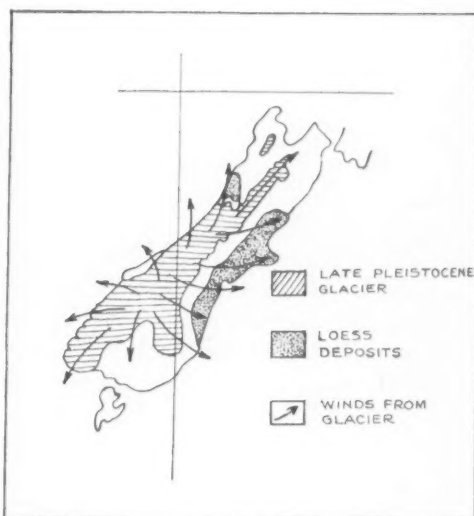


FIG. 17. MAP OF LOESS DEPOSITS IN THE SOUTH ISLAND OF NEW ZEALAND, SHOWING THEIR RELATION TO THE PLEISTOCENE ICE CAP IN THE HIGHLANDS TO THE WEST.

glacier, whereas loess deposits of desert derivation are thickest far from their source in the desert.

The loess deposits which underlie the rich wheatlands of the Middle Western states of the North American Union owe their origin to the latest of the four great continental glaciers of the past, the so-called Wisconsin glacier. This latest glacier overlay the northern part of the national domain, as well as most of Canada, during the so-called Ice Age of recent geological history (Fig. 12). Similar deposits are probably indicated by the large area of silt on the sea bottom off our Atlantic coast, south of New England, for that area was at the time a part of the continent.

Apparently at about the time the Pleistocene continental glaciers lay over North America, quite similar glaciers, likewise four in succession, lay over northern Europe. Bounded along the southern border by an extensive outwash area, loess deposits are spread out over large sections which surround the outwash, and these constitute the rich wheatlands

of Europe, including the Ukraine of southern Russia (Fig. 14). As in the case for the United States, the loess of Europe is thickest nearest the glacier and thins out at greater distances (Fig. 15). The Rhine River which flows through the loess area, has transported this material as fine silt to be deposited along its banks and carried down to the sea, and it has there contributed to the rich delta which has supplied the food to the densely populated region of the Low Countries.

The great granary of South America is the Pampas plain of the Argentine, likewise a heavy loess deposit which has been derived from the continental type of glacier that in Pleistocene times covered most of Chile and the Southern Argentine (Patagonia). Here, as in the cases of North America and Europe, the deposits are thickest over the areas close to the outwash, the wheat lands. The loess thins northward where it makes the

pasture lands of the Argentine cattle ranches. Today the winds blow summer and winter alike from the opposite quarter, or across the Argentine out of the northern hinterland where there is a rainfall of fifty to eighty inches (Fig. 16).

The main granaries of the world have been passed in review and shown to owe their fertility to the wind-deposited loess formations. There are also many smaller areas both on the margins of deserts, as in Central Asia and especially Turkestan, and in association with smaller ice caps, as in the plain of Lombardy about the River Po on the borders of the Pleistocene ice cap of the Alps. Another interesting small example is supplied by the South Island of New Zealand, where the wheat fields of the Canterbury plain are of loess deposited about the borders of an ice cap which in Pleistocene time lay to the west (Fig. 17).

ACCIDENT FACTS FROM THE NATIONAL SAFETY COUNCIL

FATAL accidents in 1941 were up 6% over 1940. Every 5 minutes, one person is killed and 90 injured in accidents in the U.S.A., at a total cost of \$38,000.

In 1941, there was one accidental death in every 342 families; one disabling injury in every 4 families, and the national cost was \$88 a family.

War death, wounded, captured and missing in the year following Pearl Harbor took about 55,000 men. But in the same year, 102,500 died in accidents—one in 1,300 people. Injuries were sustained by 9,400,000—one in 14 people. Of these 350,000 were permanently disabled and 8,950,000 temporarily disabled.

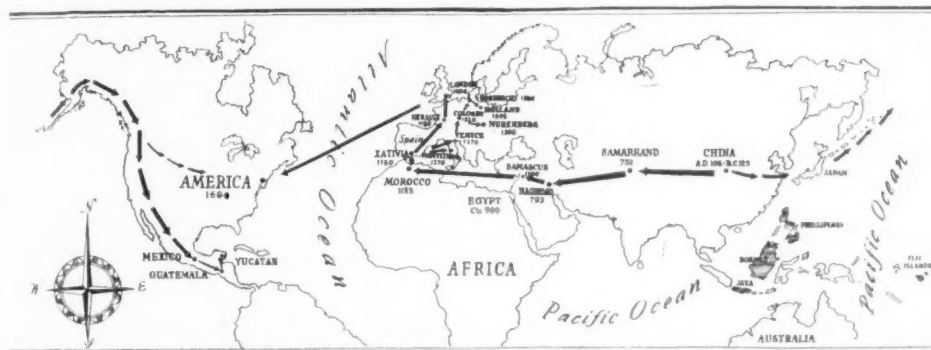
PAPER AND CIVILIZATION

By Dr. VICTOR W. VON HAGEN

SANTA MONICA, CALIFORNIA

WE live in a paper-world. Paper work—putting a thing on paper—has become the first stage in thought and action. As a space-saver, a time-saver, a labor-saver, paper has had a unique part in the intellectual development of mankind. Wherever paper, in any of its variety of forms, has touched the lives of people, it has quickened them, given living substance to their oral traditions and become the means for the creation of literature and

fiber of the mulberry, was invented by the Chinese and became the cultural medium of the Asiatics. While across the waters of the Atlantic, an American civilization (during the same period that the Chinese were perfecting their paper) had invented a smooth, white, writing surface, beaten tapa-like from the wild fig tree. Those people were the Maya, and their medium was *huun-paper*. Eventually two of these paper-worlds,



THE PATH OF PAPER BEGINS IN CHINA

BEFORE THE ADVENT OF CHRIST; TRAVELS EAST INTO EUROPE. BROKEN ARROWS INDICATE THE ROUTE OF PROTO-MONGOLIC PEOPLES TO AMERICA. THERE THE MAYA, PERHAPS EVEN BEFORE THE INVENTION OF "TRUE PAPER" BY THE CHINESE, MADE THE FIRST PAPER FROM MULBERRY FIBERS.

civilization. Yet paper did not create its role, and its part as a civilizer was not, in the beginning, a conscious one; like most cultural elements, it began by accident. And curiously enough, paper in its broad sense was invented in three geographically separate areas—Asia, the Mediterranean, and Middle America—culture areas remote from each other. Yet, in each area and in different forms, paper played its role in the intellectual evolution of people. Papyrus, although it was not paper as we use the word, was the precursor of the paper medium: it was confined to the Mediterranean. Paper, true paper, fashioned from the bast-

the Mediterranean and the Asiatic, met and then, with the European as cultural agent, these two absorbed the third—the Maya and the Aztec.

Paper and the cultures it helped to create did not follow a steady evolution. At one time, in the fifth century, two of the paper areas faced cultural involution, for intellectual night had settled over Europe. The Goths, repaying with devastating interest an earlier invasion of their realm, had swept down upon Rome and thrown into the decaying foci of civilization the barbaric Alemanni, who undid the cultural work of centuries. Old Roman gentlemen, remembering

with troubled minds their enlightened past, shrank within themselves and dug their noses deeper into the "Consolations of Philosophy."

Greece, classical Greece, was in total eclipse, while the Arabs, their intellectual heirs, were still in a state of cultural pupation. And in this epoch of involution, the Christians, swollen with fanatical zeal, inaugurated the first of their alphabetic crusades—by sacking the Alexandrian library. And even in other centers this backsliding went on, for in China the Han Dynasty was breaking up, and this brought on in China, as in the European and Mediterranean theaters, four centuries of cultural anarchy.

The lights were going out in Europe and in China, and yet, on the other side of the world, in a region still unknown, still uncharted by men or gods, the Maya, a race of Amerindians, were reaching the apogee of their civilization.

There is no precise moment in proto-history when the curtain can be raised on this civilization of Middle America, nor is there any indisputable moment when paper began to play its role. Starting sometime in the third century, B.C., the Maya had, within a few centuries, reared in the jungle the stone cities of Copan, Quiriguá, Ixkun, Holmul, Nakun, Yaxchilan and Palenque. Paths were carved out of America's green mansion; trade and commerce were carried on for incredible distances beyond the limits of Mayadom. Art and religion with which it was inextricably bound grew, along with their Government, into complex forms. Astronomy became highly developed and the knowledge of astronomical time periods, notation systems and the discovery of a permutation system of names and numbers evolved into a complex calendar: the Maya astronomers even discovered the concept of the zero. All this maze of abstract mental activity gave rise, over a long period of time, to a system of hieroglyphs which not only

extended their mnemonic processes, but assisted, as it evolved into writing, in the creation of a literature. As a corollary to writing, a smooth surface for writing had to be perfected. Thus, in some remote epoch of Maya civilization, bark-cloth tunics left the backs of the people and became "paper." This "paper," superior in texture, durability and plasticity to Egyptian papyrus, was thus perfected anonymously and communally by the Maya. And this writing surface they called *huun*.

Paper gave permanent content to the Maya civilization. Primitive tradition has its limits; faculty of speech merely makes society possible and nothing more. The invention and perfection of hieroglyphic writing and a paper on which to record it gave extension and durability to the ideas that poured from the brain of the Maya. Paper aided the endless unraveling of the intricacies of the Maya calendar and helped develop Maya writing. Paper, in the role of a sketch pad, doubtless played its part in the erection of their gigantic architectural monuments—monoliths which from year to year gained in masterly styles of decorative realism. In time paper became one of the transmissional agents of Maya civilization and, by aiding the continuity from one epoch to another, gave substance to oral traditions. The Maya accumulated books, as man had done elsewhere—in China, in Egypt, in Rome, in Greece. These books, and there were actually books, were housed and protected down through the centuries. And when decadence settled on the Maya and the Transition Period (620–980 A.D.) appeared in Maya history, a plateau people of Central Mexico, the Toltec, became the dominant cultural element. The Toltec as the master builders of Teotihuacan, of Tula and of Cholula, are revealed as excellent craftsmen and architects even though their historicity still remains tenuous in their varied



BARK CLOTH TUNIC WORN BY A JICAQUE INDIAN OF HONDURAS

THIS CLOTH WAS BEATEN FROM THE FICUS-TREE THAT YIELDED PAPER TO THE MAYA AND AZTEC.

works. With the cultural advent of the Toltec the technique of paper making doubtless improved; so did ideographic writing. Although profoundly indebted to the Maya, their writing gained in directness and simplicity, so much so that by the seventh century the Toltec had, if their "history" can be credited, a "divine book," the *Teoamaortli*, compiled at Tula in the year 660 A.D. by the astrologer Huemacín. Writing had sufficiently advanced to record in Toltec a "History of Heaven and Earth," a cosmogony, a description of the constellations, a division of time, the migrations of the Amerindian nations, a mythology and, if tradition may be regarded, a "Moral Philosophy."

Throughout all this epoch of proto-history, records in hieroglyphs were accumulated. Partly with magic, partly with techniques, like the Toltec, man everywhere sought to realize the dream of the conquest of nature. And when,

like the Maya, the Toltec went into eclipse, the Aztec nation appeared on the cultural horizon between the years 1100 and 1300 A.D. The Aztec began as a nomadic people in 1168 A.D., according to their written traditions, and came in a mass migration to the lake regions of the Valley of Mexico. Here in Lake Texcoco they expanded gradually, enlarged the commanding island of the Lake and called it Tenochtitlan, the place of Tenochas. With a judicious use of rapine, bribery and statecraft, they enlarged this realm beyond the confines of the Valley of Anahuac. As the Romans took over Greek trade and culture, so did the Aztec take over the Toltec and their prerogatives. Under the Aztec much of Middle America became systematized. Trade was extended; so were the levies of tribute. All this called for records, written records. In no civilization theretofore in the Americas was there so insistent a demand for paper.

Paper was needed to record tributes, to mark the villages and cities tributary to Tenochtitlan. Paper was needed for legal documents. Paper, made into rolls thirty feet in length, was used, as by the scribes of the ancient Goths, to record methodically the accretions of their conquests. Paper took on, as it did with the Chinese, a religious and ceremonial character. Folded like a miniature screen, it was sized, made into books called *tonalamatts*, and housed at the libraries of Texcoco. And, finally, paper was used as tribute. Entered in one of the most famed of Montezuma II's tribute charts—the *Codex Mendoza*—there is recorded this highly significant item: "Twenty-four thousand reams of paper are to be brought yearly to the storehouses of the ruler of Tenochtitlan."

"Twenty-four thousand reams of paper!" Judged by any standards of a primitive civilization, such a quantity is enormous even though the Spanish word *resmas* is nothing more than an expression which fortuitously coincided with the Aztec numeral, *pilli*, or twenty. Twenty-four thousand reams," or 480,000 sheets of paper, in sum, was then to be paid annually in tribute to Montezuma II. This enormous consumption of paper by the Aztec would then seem to suggest that paper making had left the craft stage and had entered that of industry. It also brings up a question which students of history must have already asked themselves: Paper in America! Was not paper a Chinese invention?

It has been shown by Stein and Carter, and more recently by Dard Hunter, that paper *was* a Chinese invention. Hunter writes, "The Chinese eunuch Ts'ai Lun, in the year A.D. 105, proclaimed his marvelous invention of true paper—a thin felted material formed upon flat porous moulds from macerated vegetable fibre." And from China true paper penetrated both ends of the Taklamakan desert

until, by the fifth century "true paper" was in general use throughout Central Asia, and within six centuries paper became general through Asia Minor and began to appear in Europe.

Paper then becomes a matter of definition, and before its dissemination can be followed, it must be agreed on as to just what paper is. Paper, in point of illustration, has two definitions—the cultural and the technical. Paper can not be wholly limited by the process of its manufacture, since paper in its cultural definition is not contained in a purely technical description, for neither the papyrus of the Egyptians nor the *amatl-paper* of the Aztecs nor the *huun-paper* of the Maya was actually "paper"; that is, paper as we now understand it.

"True paper," reduced to an encyclopedic definition, is a more or less thin tissue composed of any fibrous material whose individual fibers, first separated by mechanical action (beating, pounding, etc.), are then deposited (actually felted) on a mould while suspended in water. This "true paper" was first invented by the Chinese. It was the Chinese who devised the implement—the paper making mould—which was capable of picking up the masticated fibers. This mould was so constructed as to allow the water to escape, thus leaving the interwoven fibers in an even homogenous mass which, when dried, pressed and sized, became paper. This has remained throughout the centuries the principal technique of paper making, and upon this principle the modern paper machine is founded. Not only did the Chinese invent and perfect true paper, but from the heart of China began the westward march of paper. The secret of paper manufacture was taught by Chinese paper-making prisoners while captives of the Arabs at Samarkand where they were defeated in battle in 751. This is confirmed in the annals of the T'ang Dynasty. It was the be-

ginning of the march of paper from Samarkand to Baghdad, then to Damascus, Morocco and finally to Europe via the Spanish peninsula, with the Moorish invasion in 1193.

Gradually, through the thousand years of its development, paper displaced silk, papyrus and parchment, and when it finally became "fixed" in Europe after the invention of moveable type, it supplanted all other writing substances—and upon "paper" European civilization became predicated.

Yet, other civilizations reached great cultural heights without the knowledge of true paper. The Egyptians and Syrians manufactured papyrus, the Mayas, *huun-paper*, and the Aztecs perfected their *amatl-paper*, so that in default of the techniques of true paper, they developed a writing surface by means of which they were able to transmit knowledge from the brain of one to another. This materially affected civilization. While it is not necessarily true that the quantity of paper consumed stands in direct ratio to the intellectual development of a nation (for the Inca civilization had neither paper nor writing), it is nevertheless true that man's intellectual rise has been astride the fibrous material called paper, no matter what its mode of manufacture. Whether it was couched in a mould, as was the Chinese paper, or pressed into a laminated substance, as was papyrus, or beaten from the inner bark of the wild fig tree, as was the *amatl-paper* of the Aztecs, it served for writing which, once perfected, freed communication from the limitation of time-space factors.

The invention of paper, in its broad sense, removed the necessity for face-to-face contact. It allowed the knowledge gained by each man to be set down in a permanent record. Compared with verbal communication, the written page increased the safety and the permanence of oral transmission, and, since copies



PAGE FROM THE CODEX MENDOZA

could be made, writings could extend communications and give thought a new dimension. It is from the inventions, first of writing and then of printing, that we may date the most important factors of civilization, since paper and writing caused man's experience to be projected beyond his own epoch.

Thus it was that, centuries before Ts'ai Lun of Human Province perfected the paper mould and therewith paper, the Egyptians discovered (ca. 350 B.C.) that by laminating strips of the stems of *Cyperus papyrus*, a plant cultivated in the delta of the Nile, they could fashion a smooth writing surface. Away went bones, wood and clay tablets. Writing technique improved and passed from the hieroglyphic to the phonetic. By learning to paste the two rough sides of the laminated paper together, they were able to make rolls of papyrus six to twelve inches wide and forty feet in length, a direct parallelism to be found



MOST ANCIENT KNOWN PAPER
CHINA, EASTERN HAN PERIOD (A.D. 25-220).

three thousand years later in the techniques of *huon-paper* manufactured by the Maya. With papyrus and writing, an extensive literature was created, one that embraced music, astronomy, cosmogony, geography, medicine, chemistry and magic. Even mathematics was reduced to writing, permitting the Egyptians to compute correctly the areas of triangles, rapeziums, and of frustums and squares of pyramids. The dramas of Osiris were put into the long scrolls

and even the spicy tales of Sinbad the Sailor were encompassed in a roll of papyrus forty feet long.

Everywhere the Mediterranean peoples took up papyrus; the Assyrians, the Persians, and of course, those transport-agents, the Phoenicians who introduced into Greece not only the alphabet¹ but also papyrus. This created the written literature of Greece.

All the separate streams of knowledge in the ancient world converged on Greece, there to be filtered and purified, extended and developed. The Greeks were rising to Parnassus on paper-wings.

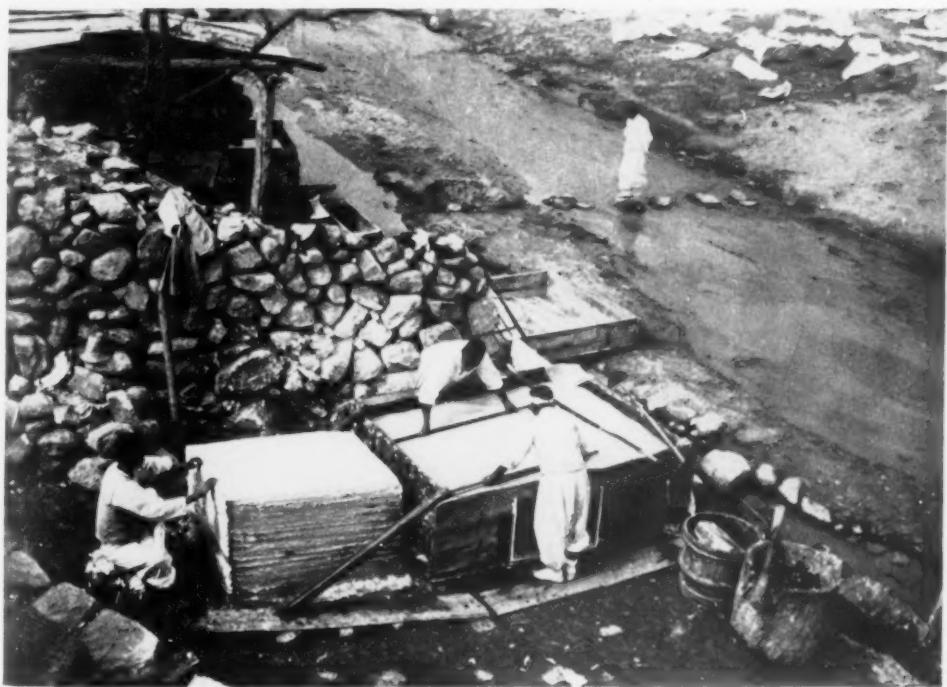
By the middle of the third century B.C., the famous Alexandrian Museum had been founded by the Ptolemies. Dedicated to the Muses of literature, mathematics, astronomy and medicine, they were developed and served by a library of 400,000 volumes. Four hundred thousand scrolls and books! The intellectual motes were dancing in the sunbeams of the Mediterranean and making themselves visible in every direction. Papyrus, in the role of paper, had released the intellectual energies of man.

Through the centuries paper and civilization continued their parallel march. There were lacunae, to be sure, and cultural involutions, but whenever an epoch of anarchian violence ended, learning (now attached irrevocably to paper and writing) continued to thrust itself forward. Europe, had need of paper. In the great scriptoriums of the medieval abbeys, the making and copying of books were clerical vocations. Yet the paper crisis in medieval Europe kept pace with the intellectual crisis, for papyrus, which for two thousand years had been a major import into Europe, abruptly ceased being available. Islam had become mistress of *mare nostrum*. From that time onward the Mediterranean, natural chan-

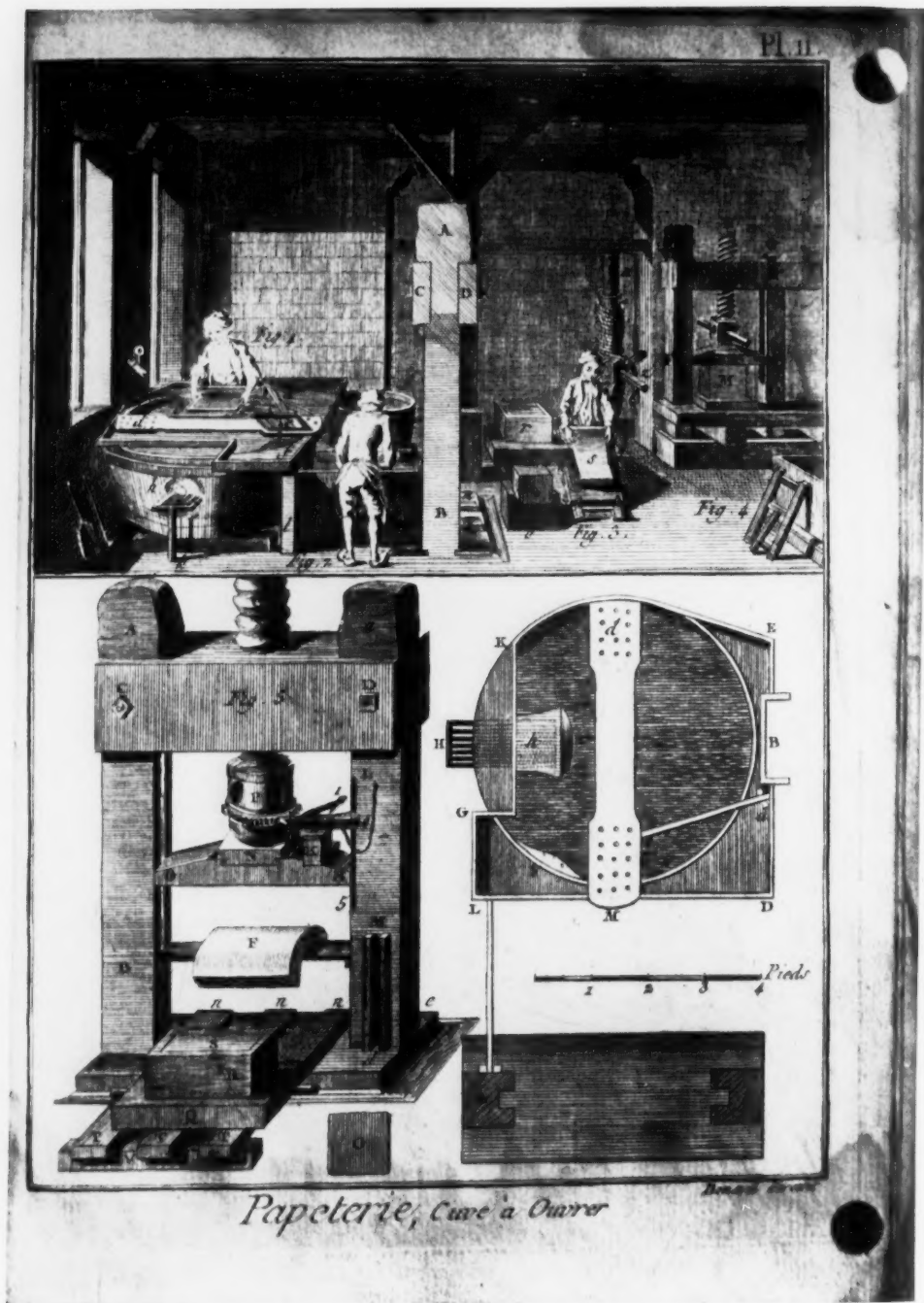
¹ A twenty-one lettered alphabet adapted by the Phoenicians from Semetic-Egyptian hieroglyphies and introduced into Europe in 1600 B.C.



TIBETAN WOMEN DRYING PAPER ON MOULDS



FORMING A SHEET OF PAPER IN THE VILLAGE OF OMPEI, KOREA



Massachusetts Institute of Technology

INTERIOR OF A FRENCH PAPER MILL OF THE EIGHTEENTH CENTURY
SHOWING A VATMAN, THE COUCHER, AND LAYMAN WHO SEPARATES THE SHEETS FROM THE FELTS.

nel of intercourse between Asia and Europe, became, instead, a barrier. While the monk copyists scrambled for the last bits of papyrus, parchment was brought forward as a papyrus substitute.

Parchment (or more properly *pergamena*) had been invented as early as the second century B.C., by the Pergamene kings of Rhodes and the City of Pergamon in western Asia Minor. For Alexandria, as a seat of learning, was not without a rival, and the enmity between Alexandria and Pergamon became so heated that to prevent the latter from acquiring copies of their literary treasures the Ptolemies put an embargo on the exportation of papyrus. To counter this, the people of Asia Minor prepared skins and developed them into *membrum pergamenum*. When the Dark Ages closed about Europe and when papyrus was again denied Europe by an expanding Moslem Empire, the monks could and did fall back on parchment.

So, while medieval Europe was papyrus-starved, the Chinese, who invented paper in the second century A.D., had by now perfected its inevitable corollary, the perfected block-printed book. In the memorable year 868 A.D., Wang Chieh, in order to perpetuate the memory of his parents, had the "Diamond Sutra" printed on a scroll for free general distribution. It was the first printed book and the invention spread like an unchecked fire throughout Asia, only to come to a halt at the Mediterranean.

The Chinese paper makers taken captive by the Arabs in the eighth century, brought their technique to the Near East, as noted above, and in a short time "Paper of Samarkand" became so well known throughout the Asiatic dominions of the Caliphate that in the century following its introduction an Arabian chronicler was writing: "Among the specialties of Samarkand that should be mentioned . . . is *paper*. It has replaced the rolls of Egyptian papyrus

Der Papierer.



Ich brauch Hadern zu meiner Mül/
Dran treibt mirs Rad des Wassers viel/
Daf mir die zſchnittn Hadern nelt/
Das Zeug wirt in Waſſer cwnquelt/
Drauf mach ich Boagn/auff den Fils bring/
Durch Preſſ das Waſſer darauf zwing.
Denn hend ichs auff/laß drucken wern/
Ehne weiß vnd glatt/ſo hat man gen.
J n Der

EARLIEST VIEW OF A PAPER MAKER
MADE IN EUROPE. FROM THE BOOK-OF-TRADES,
GERMANY, 1568. ENGRAVING BY JUST AMMAN.

and the parchment which were formerly used for writing because it is more agreeable and convenient. It is found only here and in China."

The religious wars between Islam and Christianity prevented Europe from obtaining, for centuries, the "new papyrus," or true paper, which was being manufactured in 793 A.D. in exportable quantities in Baghdad, Damascus, and Bambyx. The Arabs, translators of Galen, Euclid, Aristotle and Hippocrates—the Arabs, intellectual heirs of the Greeks, Master of Islam and Mistress of the Mediterranean—were now from the eighth to the twelfth centuries carrying the cultural torch; they had writing,



RUINS OF CHICHEN ITZA
HERE THE MAYA CREATED THE DRESDEN CODEX.

paper and enthusiasm. Some anonymous scholar at this time even prepared a manual called *Umdet-et-Kuttab*, which dealt not only with ink and writing, but also with the manufacture of paper from bast fibers of mulberry, flax and hemp. But all this was a closed book, actually and figuratively, to Europe; closed as much by Christian opposition to all things Islamic as by the holocausts left by the Crusades. The printed book, which had followed paper across the trade-routes from China to Asia Minor, stopped also at Islam. The Arabs, everywhere leaders in astronomy, materia medica, mathematics and grammar, as well as being the repository of Greek learning, accepted as a firm religious axiom: "The Koran was written by hand; it must continually be written by hand. What is good enough for the Koran must also serve for any other book."

Perhaps the Arabs suspected that the printing block was cleaned by hog-bristles; more likely printing collided

with tradition, and tradition won. Yet, for the moment, it meant little to the spread of learning; paper and civilization marched on in an inseparable combination, an intellectual mesh, so overlapped and blended, like the chiaroscuro of shadow and light, that the two, paper and civilization, formed, it might be said, an intellectual symbiosis. Then gradually, as the Arabs expanded, they overflowed from the Mediterranean into the Spanish peninsula and so brought paper to Europe by establishing the first paper mill at Xativa, Spain, near Valencia, in 1150 A.D.

The Arabs were entering Europe and bringing paper, which would, in the fullness of time, help to create the renaissance. So, in the same era, the Toltecs in Middle America, under the cult of Quetzalcoatl, had begun to move northward and downward from the Mexican plateaux toward the Yucatan Peninsula. There the Maya, still in eclipse, had started to rebuild the City States of Uxmal, Labna, Kabah and Chichen Itza, under the inspiration of the League of Mayapan. This league of cities (between 980 and 1200 A.D.) was characterized by the revival of architecture, the spread of paper making and the execution of ideographical books. With the intrusion culture of the Toltec enveloping the Maya, the renaissance took hold among the people. Elaborate stone cities fronted with a façade of the plumed-serpent motif lifted themselves above the limestone soil of Yucatan. The cultures of the highland Toltec and the lowland, jungle-locked Maya had met. Techniques had improved, so had ideographic writing. The Maya began to fold their *huun-paper* into book form, and there was produced in this period (somewhere between 990 and 1100 A.D.) the "Dresden Codex," a sacred almanac of seventy-five pages which was set down by some anonymous astronomer-priest of Mayapan.



FIJIAN WOMEN DECORATING "TAPA," A FORM OF PAPER

BEATEN FROM THE BARK OF THE MULBERRY TREE AND USED VARIOUSLY IN THE PACIFIC ISLANDS.

Back and forth ebbed the tides of domination. Eventually that which had been the exclusive property of one tribe became the common cultural currency of all Middle America. Whether the Maya, Toltec, Zapoteco, Totonac or Aztec—all by the fourteenth century possessed hieroglyphic writing, all were paper makers, all had calendars, and ideographic-histories and their sacred *tonalamatls* or almanacs reduced to book form.

Under the last Aztec ruler, Montezuma II, the use of paper had expanded until it became culturally linked with the production of art, writing and ritual, and part and parcel of the multifarious rituals of Aztec life. Paper was used first to supply the need of artist-astronomers and for historical annals and then for the register of tributes, for map-drafts and for the delineation of land-holdings. Further, *amall-paper*, left the abstract of record and entered the sphere of ritual. Among the Aztecs paper ap-

peared in every form of ritual. In the festivals to celebrate the first month, Atlacoalo, large poles were raised (writes Padre Bernardo Sahagun) on the top of which were hung colorful strips of paper. In the fifth month, *Totcatl*, the festival of the God, Tetzcatlipoeca, there were "young girls . . . bearing canes with paper tassels at the top," and noblemen who "wore rosettes made of paper on their foreheads and around their waists, little aprons of paper, called *amasmarlli*." In every month dedicated to a god, paper was used in hundreds of forms. Eventually paper itself became to the Aztecs, as to the Chinese, something sacred.

Paper-making villages sprang up all over Mexico. These small villages, Tepoztlan, Amacoztitla, Iztacamatitlan, still exist and are still surrounded by the same wild fig trees that yielded their inner fibers from which *amall-paper* was made. So ingrained was the



AZTEC WOMEN OF CHICONTEPEC MAKING RUSSET PAPER FROM ACACIA

art of paper making that even to-day in remote villages of Vera Cruz and Hidalgo the Indians still secretly carry on the manufacture of paper. Nothing has changed in either their choice of tree or in their use of the old instruments; all this, as the illustrations show, is a heritage of the paper world of the Aztecs.

This parallelism of paper and civilization continued then on both sides of the Atlantic. Although the writing of the American Indians was still in its hieroglyphic stage and paper techniques were still primitive, the ritual-intoxicated priest-craft confined "books" to traditional moulds; Thus their progress was not continuous.

Europe was, in a sense, in a somewhat similar state. Paper, which almost everywhere had been the forerunner of printing, made slow headway, for which there were several reasons. First, the guild of parchment makers, who, after having nurtured parchment to meet the lack of papyrus, now opposed the introduction of a paper which would spell the doom of their craft. Secondly, there was a prejudice against paper because of its Judeo-Arabic source; but more, its spread was retarded by the lack of materials from which paper could be made. Until Europeans began to wear linen underwear rather than woolen, suitable rag-waste could not be obtained from which to fashion paper. Marco Polo, returned from Asia, had written about Chinese paper-making materials, yet none of the paper-making technicians had consulted him. Of Chinese paper he had written:

... They ... take the bark of a certain tree, in fact of the Mulberry tree, the leaves of which are the food of the silk worms,—what they take is a certain fine bast or skin which lies between the wood of the tree and the thick outer bark and this they make into something resembling sheets of paper.

Even the Arabs had suggested hemp, flax and mulberry; yet the techniques of

paper-making were still undeveloped—so the early paper makers turned for paper to the rag waste of underwear, the easiest thing to obtain. This method of using underwear brought a snort from the parchment makers and a censure from the god-fount. Petri Venerabilis, the Abbot of Cluny, while on pilgrimage to Compostela, visited a paper mill and his soul was shocked by the materials from which paper was made: "God," the disturbed Abbot is said to have written, "reads the book of Talmud in Heaven. But what kind of a book? Is it the kind we have in daily use made from the skins of rams or goats, or is it from rags of old cast-off undergarments, or rushes out of Eastern swamps, and some other vile material?"

The parchment makers guild was deeply thankful for this spiritual assistance in their fight against the now encroaching paper makers. Paper thus spread slowly from Spain to Italy to France and then into Germany. But in Europe paper was everywhere the forerunner of printing. Without this strong, economical material, printing could never have made headway. Follow the path of paper and you also follow the path of printing. So on the eve of the Renaissance we find Ullman Stromer outside the walls of Nuremberg, on the river Pegnitz, establishing a paper mill and setting the paper scene for the rebirth of the spirit.

The fourteenth century was the early dawn of the modern world. It is a century that sings with the hymnal of the new life. Chaucer sang of it in England, with all its matutinal freshness; Dante gave it a richer, deeper, more human feeling in Italy. All over Europe the cathedral builders were reaching their triumph. In Florence and Flanders, art was waking from its thousand-year sleep. In religion the century had begun with the simplicity and beauty of the early followers; it closed with the deep moral

earnestness of Wyclif, Savonarola, Luther, Huss. The nascent spirit had begun; the religion of spirit was breaking free. Already block-printing had begun in Germany, Holland and Italy. Like those of the Chinese and the early chronicles of the Maya, the Toltec and the Aztec, the first books of Europe were religious. Book making or printing (irrespective of where or under whom it began) has always been dependent on great manifestations of religious feeling. In the whole cultural history of books, whether they be the holograph type of the Maya and the Aztec, the block-print book of the Chinese, or the books of Europe made from moveable type—the beginnings were born of the religious spirit. The first book printed from moveable type was the Bible of Gutenberg. Religious books began the advance; classics continued it.

As soon as the printing press showed what it could do, parchment ceased to be important. Paper was ushered into the European theatre and paper mills mushroomed up everywhere in Europe. Between the first printed book, in 1450, and that fateful day of 1492, three million books had left the European presses. While printing and publishing did not create the Renaissance, it none the less gave impetus to it and then held its advance. It released people from their

medieval nightmare and freed them from the domination of the immediate—and the local. Man now became curious; he wanted knowledge. What is the earth and where does it end; what lies on the other side of the waters? The concatenation of paper, printing, curiosity and nascent man brought on extensive exploration. Holograph manuscripts that had been in the possession of the few, came out into the open and in printed form. Maps and charts left the archives and became popular currency. *Imago Mundi*, published in 1460 (and a favorite of the man Cristóbal Colón), gave impetus to the understanding of the planets. Theatetus published his trigonometrical tables. Cardan, Tartaglia, Scipio Ferrero and Stefel were improving algebra. Men no longer feared the sea nor believed the earth flat. Legends of austral regions across the Ocean-Sea were set in print and became the talk of men. There was a frenzied scurrying of kings and navigators, adventurers and explorers and talks of new routes to the Indies, of strange islands. New discoveries were loose in the world. Man read and dreamed; and one, Cristóbal Colón, more practical than all others, seized upon the dream and stole out into the unknown Ocean-Sea. The isolation of the Americas came to an end. The paper-worlds had met.

AGASSIZ'S SCHOOL ON PENIKESE

SEVENTY YEARS AFTER

By LOUIS C. CORNISH

HARVARD, MASSACHUSETTS

LOUIS AGASSIZ triumphed. He had been leading the forlorn hope of a summer school. Suddenly, within a few days, and from unexpected sources, he received the gift of an island, a fund of \$50,000, and the use of an ocean-going yacht. His dream at once was to become a reality. Marcou calls the enterprise "the most extraordinary episode of Agassiz's life."¹

There had been talk of founding a scientific summer school. Nathaniel Southgate Shaler, Agassiz's younger colleague at Harvard, had proposed "a scientific camp meeting on Nantucket." There had been a heralding of possibilities, and a sequence leading up to the event.

In 1871 the United States Coast Survey sent a ship around Cape Horn to California, and back again, for deep-sea dredging; Agassiz was asked to make the trip, and he went. The voyage lasted from December 1871 to August 1873, and was not particularly fortunate, but it gives us an unforgettable picture. Thomas Hill, formerly president of Harvard, also went on this voyage, and he tells us how Agassiz sat upon the edge of his berth most of the night they sailed, "talking, talking, talking," while the ship fought her way out of Boston Harbor through a snowstorm into a heavy sea. Agassiz was telling of his hopes for the future of science and the methods of teaching it. No doubt among them was his plan for a summer school to teach the scientific method. He left the ship at San Francisco and returned overland. On his way he stopped for two months

at Ithaca, where "a new college called Cornell" was just emerging into its distinguished career. He was promptly made a non-resident professor with the duty of giving annually a brief course of lectures, and he promptly accepted the appointment.

"In October, 1872," Mrs. Agassiz tells us,² "Agassiz returned to Cambridge. He found a new scheme of education on foot, one for which he himself had given the first impulse, but which some of his younger friends had carefully considered and discussed in his absence, confident that with his help it might be accomplished. The plan was to establish a summer school of natural history somewhere on the coast of Massachusetts where teachers from our schools and colleges could make their vacations serviceable by the direct study of nature." David Starr Jordan gives a more explicit account.³ "During the previous winter," he says, "Agassiz had cast about for some means of coming into contact with American teachers of Zoology, and so exerting an influence toward better methods; for in those days science teaching in the secondary schools, and even in the colleges, was of a very inferior order, without laboratories, and for the most part lacking contact with nature herself. Up to that time nothing of the sort had anywhere existed. But he conceived the idea of meeting teachers at the seaside, away from all other influences, believing that he could thus make clear to us the necessity of going directly to nature, the

² Elizabeth Cary Agassiz, *Louis Agassiz, Life and Letters*, Vol. II, p. 265.

³ David Starr Jordan, *The Days of a Man*, Vol. I, p. 107.

¹ Jules Marcou, *Life and Letters of Louis Agassiz*, Vol. II, p. 201.

fountain head—thus teaching us to recognize the truth as truth, to know that there are facts in the universe which, as Huxley says, are 'fundamentally beyond denial, and to which the tradition of a thousand years is no more than the hearsay of yesterday.' "

Agassiz and his colleagues were contemplating an important advance in the methodology of education, but how to finance it was the question. Always an optimist, Agassiz decided to approach the Legislature of Massachusetts, which then had the pleasant habit of making an annual visit to the Harvard Museum in the month of March. We can all but see the fifty members of the General Court as they walked from the State House down Park Street to Tremont where their ten horse-cars were waiting, and then slowly proceeded to Cambridge over roads that now seem indirect, for the present bridges over the Charles River had not yet been built, nor the tunnel beneath the river even conceived. The trip took about an hour, against the eight-minute run of today. Walking from Harvard Square to the Museum they may have arrived wind-blown and weary. Agassiz welcomed them, showed them about, and then settled them in the lecture hall. Here was Agassiz's strategic chance. Would they give him money for the school? He could only try. So he appealed for funds sufficient to start a summer school of science somewhere by the Massachusetts seaside. We do not know whether or not they were favorably impressed, although one legislator bore this testimony, "I don't know much about Agassiz's Museum, but I am not willing to stand by and see so brave a man struggle without aid." All that the legislators could do at the time was to promise to consider the whole matter. So they walked back to Harvard Square, boarded their ten waiting horse-cars, and made the jogging journey back to Boston and the State House; thus they pass out

of our history. There was no need of their voting money for the school by the seaside. The unexpected happened.

The evening newspapers carried an account of the legislators' visit to the Museum, and of Agassiz's plea for the new summer school of science. The next morning Mr. H. A. Anderson, a public-spirited and wealthy New Yorker, read the report in the morning newspapers and promptly presented Agassiz with fifty thousand dollars and the island of Penikese. To these gifts Mr. C. W. Galloupe, of Boston, added the use of his ocean-going yacht, "The Sprite." All this happened within a few days, and Agassiz was free to start what Dr. Jordan calls the most important work of his life. And now began the first summer school in the country.

What sort of a place was his island? "Penikese," says Dr. Jordan,⁴ "a little forgotten speck on the ocean, about eighteen miles from New Bedford, is the outermost and least of the Elizabeth Islands which lie to the south of Buzzards Bay, off the heel of Cape Cod. It comprises some sixty acres of very rocky ground, being indeed only a huge pile of stones with intervals of soil. . . . It consists of two hills joined together by a narrow isthmus with a little harbor of anchorage; in June, 1873, it bore a farmhouse, a flagstaff, a barn, a willow tree by a spring, and a flock of sheep." But the island was not as negligible as we might infer. "The shores yielded Agassiz untouched pools of sea life," says Robinson, "and gave him fresh research material." The complete solitude afforded was most desirable for the kind of school he was starting. The waters of Buzzards Bay lay on one side of the Island and the whole Atlantic on the other. Agassiz was well content.

On April 22, 1873, accompanied by members of the city government of New

⁴ David Starr Jordan, *Days of a Man*, Vol. I, p. 108.



LOUIS AGASSIZ (1835-1910)

Bedford and a number of invited guests, he sailed across Buzzards Bay and, welcomed by Mr. and Mrs. Anderson who had come on from New York, he took possession of his island. Shortly afterward he announced that the school would open on July 6, leaving a bare two and a half months to complete all the arrangements.

Building materials and labor were hard to transport, and proved costly, but Agassiz's enthusiasm accomplished the opening of the school on the date that had been set. A laboratory was put up, a long, narrow one-story affair. A dormitory was built which contained little more than beds for thirty-five men in one division and fifteen beds for women in another. The rooms were bare, showing the framework and outside boarding. A new floor was laid in the old barn, the horse stalls having been torn away to make space for the kitchen. Three long tables filled the big room which was used for dining and as the lecture hall, the wide doors always left open to the sea. To these accommodations and surroundings Agassiz welcomed his fifty students selected from hundreds of applicants. Obviously they were a picked group far above the average in intelligence and purpose.

Here Agassiz was to teach them to go to nature herself for truth. This was then an unfamiliar method, and the fact needs emphasis. College laboratories were non-existent, and the teaching of science was from textbooks and by rote. Shaler used to tell of a student who found three shells, two wholly unlike, the third with characteristics of the other two. The two shells that were unlike he found duly listed in the textbook. The third, somewhat resembling the other two, was not on the printed list, so he destroyed it. The list was the thing, not nature showing facts! Compare this incident with the statement of William James who some years before had accompanied Agassiz on a sixteen-week

voyage up the Amazon, and knew him well. "Agassiz's influence on methods of teaching," he tells us,⁵ "was prompt and decisive. . . . The good old way of committing abstractions to memory seems never to have received such a shock as it did at his hands. He used to lock a student up in a room full of turtle shells, lobster shells, or oyster shells, without a book or word to help him, and not let him out till he had discovered all the truths which the objects contained. Some found the truths after weeks and months of lonely sorrow, others never found them. . . . Go to nature; take the facts into your own hands, look and see for yourself! These were the maxims which Agassiz preached . . . and their effect on pedagogy was electric." This method was to be used at Penikese.

"It was amusing to see Agassiz delivering his lectures," says Marcou.⁶ "He was surrounded not only by forty-four students, of both sexes, but by the workmen who were finishing the laboratory arrangements and erecting a new building. . . . Everyone was collecting, examining with microscopes, dissecting, or watching marine animals in aquaria improvised out of pails and buckets. Agassiz lectured nearly every day, and frequently twice a day; and his passion for teaching had full play. . . . (Mrs. Agassiz, note book in hand, attended every lecture.) The Sprite was fully equipped, Pourtales took charge of her (Count Louis de Pourtales, an early associate and life-long friend of Agassiz), and at once began dredging, going out daily, weather permitting, with eight or ten students, and obtaining a variety of specimens which could not be procured from the shore."

Two incidents in the early days of the school give us glimpses of Agassiz's personality. One shows an almost ruthless

⁵ William James, *Science*, n.s. 5: 285.

⁶ Jules Marcou, *Life and Letters of Louis Agassiz*, Vol. II, p. 201.

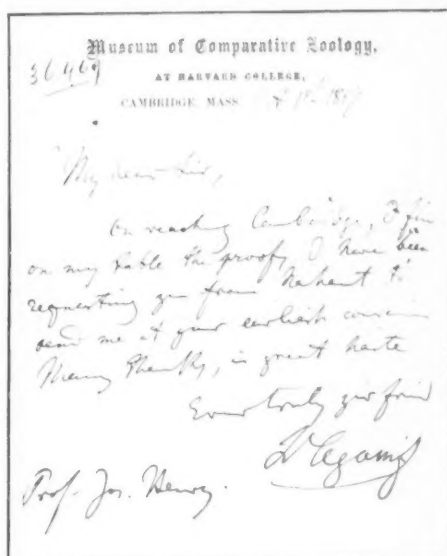
power in eliminating hindrances, the other expresses his religion.

He had admitted women to the school. Coeducation in those days was generally frowned on and often resented. Some of the men students on Penikese would have preferred to have women excluded, and they decided, as Jordan expresses it, "to teach Agassiz a lesson." They rigged up a pillow as a doll baby and late at night threw it over the blankets that hung on a rope and divided the sleeping quarters. This happened in the laboratory, where everyone slept for the first few nights, the dormitory not being finished. Of course, tossing the pillow caused a commotion on both sides of the curtain. At breakfast the next morning Agassiz arose at his place and read the names of six men who would leave the island on the steamer at ten o'clock. Pleas were made on their behalf, the incident was no more than a student's prank, and the like, but Agassiz answered that the island was not a place for students' pranks and he refused to let the men remain.

Dr. Jordan tells us of the other incident.⁷ "Our second day upon the island," he says, "was memorable above all others. Breakfast over, Agassiz arose and spoke, as only he could speak, of his purpose in calling us together. The swallows flew in and out of the building in the soft June air. Some of them grazed his shoulder as he dwelt with intense earnestness on the needs of the people for truer education—needs that could be met by the training and consecration of devoted teachers. This was to him no ordinary school, he said, still less a mere summer outing, but a missionary work of highest importance.

"A deep religious meaning permeated his whole discourse, for in each natural object he saw 'a thought of God.' But no reporter took down his words, and no one could call back the charm of his

⁷ *Ibid.*, Vol. I, p. 110.



LETTER TO JOSEPH HENRY

manner or the impressiveness of his zeal. At the end he said—with a somewhat foreign phrasing—"I would not have anyone to pray for me now," adding, when he realized our failure to grasp his meaning, that each would frame his own prayer in silence."

Whittier immortalized the incident in his poem, *Agassiz's Prayer*. It follows in much abbreviated form:

On the isle of Penikese,
Ringed about by sapphire seas,
Fanned by breezes salt and cool,
Stood the Master with his school.
Said the Master to the youth:
"We have come in search of truth,
Trying with uncertain key
Door by door of mystery;
We are reaching, through His laws,
To the garment hem of Cause,
Him, the endless, unbegun,
The Unnamable, the One
Light of all our light the Source,
Life of life, and Force of force.
As with fingers of the blind,
We are groping here to find
What the hieroglyphics mean
Of the Unseen in the seen.
Then the Master in his place
Bowed his head a little space.
Not for Him our violence
Storming at the gates of sense,

His the primal language, his
 The eternal silences!
 Even the careless heart was moved,
 And the doubting gave assent,
 With a gesture reverent,
 To the Master well-beloved.

The students soon fell into a pleasant routine. Each morning after breakfast they tramped the island, collecting in their pails and buckets creatures new to their unaccustomed eyes from the pools by the shore and the deeper waters at the landing. Eight or ten of them went out daily on the *Sprite* collecting from the ocean. No doubt this was a valuable experience, but many of them found it trying when the yacht, moving slowly with her dredge, for long hours rolled heavily on the southerly swells. The little island probably never had known so many visitors at any one time since it had been made by the glacier; certainly never before had it had visitors comparable in intelligence and purpose to these forty-odd young people, and to Agassiz and his companion teachers.

Our records are very sketchy, but here and there we glimpse the more personal side of the students' experiences. Writes Dr. Jordan, "Lydia W. Shattuck, professor of Botany at Mount Holyoke, was a great favorite, as was also her assistant, Susan Bowen, who in 1875 became my wife."

It would be a long digression to tell what happened to the students in later life. It must suffice to say that they were leaders in science. Dr. Jordan was perhaps the most distinguished of them all. For the last thirty-four years of his life he was president and then chancellor of Stanford University.

In the library of the University of California at Berkeley is a small folder containing newspaper clippings and a few letters about the school, at most a meager little collection. But it shows a moving touch of nostalgia. "What a wonderful time we had on Penikese, what a rich experience it was, what a high spot

in our lives! Never again shall we have the like!" Such is the tone of the little collection; only whispers and echoes of whispers, yes, but none the less precious testimony.

"The summer went on," says Jordan, "through a succession of joyous mornings, beautiful days, and calm nights, with the Master always present, always ready to help and encourage, and the contagious enthusiasm which surrounded him like an atmosphere never lacking. A born optimist, his strength lay largely in a realization of the value of the present moment. He was a living illustration of Thoreau's aphorism that 'there is no hope for you unless the bit of sod under your feet is the sweetest in the world—in any world.'"

All too soon the weeks of high comradeship and hard work came to an end. There was no commencement, no giving of credits toward degrees. All work had been done for truth's sake, and what a deep and lasting experience it had been. How fortunate long ago were the students who walked with Plato in his porch! Just Plato and the porch; in retrospect one of the noted universities of the world. How fortunate were those students of yesterday who walked with Agassiz on his island; their experience was hardly more than just Agassiz and the island, an education of great and lasting worth.

Agassiz was not to return. He died in December. Whittier's poem continues,

In the lap of sheltering seas
 Rests the isle of Penikese;
 But the lord of the domain
 Comes not to his own again:
 Where the eyes that follow fail,
 On a vaster sea his sail
 Drifts beyond our beek and hail.

The next summer there was a second and last session of The Anderson School of Natural History. Students came and worked hard under able teachers, but without the Master it was not the same school. A sense of loss and loneliness

prevailed. One evening they all gathered in the old barn and those who had been there before talked of Agassiz. One of them said, "He was the best friend that ever student had." They wrote on strips of cloth and put on the walls mottoes taken from his talks. Here are a few of them:

Study nature, not books.

Be not afraid to say, "I do not know."

Strive to interpret what really exists.

A laboratory is a sanctuary which nothing profane should enter.

These phrases were left on the walls of the empty building for fifteen years and were then carried by Eigenmann, a student of Jordan's,⁸ to the Marine Station at Woods Hole, which in a way is a successor to Agassiz's school.

No more money was forthcoming. Without Plato, what would his porch have amounted to? Despite an able faculty at its second session, it may be questioned whether the school without Agassiz could have continued even had the money been given. With all credit to the others, the island without the Master would have been very different from what it had been with him there.

What followed the school on Penikese, raised for a brief time to scientific fame, and then dropped into a sea of solitude? The school buildings never were used again. Some twenty years after the closing they were struck by lightning and burned to the ground. In 1905 the Commonwealth of Massachusetts bought the island for \$25,000 for the isolation and care of lepers. Up to 1921 some twenty unfortunates were received, all from foreign parts, Greece, the Cape Verde

Island, and China among other places, except two who were American soldiers. In that year they all were transferred to the national leprosarium at Carville, Louisiana, where all lepers in the United States are cared for by our national government. It is to be noted that during the sixteen years when the island was the place of detention for lepers, medical scientists followed the strictly scientific methods taught by Agassiz in their effort to find a cure for leprosy. Massachusetts still owns Penikese and of recent years has made it a bird sanctuary.

Says Whittier, "In the lap of sheltering seas rests the isle of Penikese." With appreciation for the necessities of poetic license, those who know the waters around Buzzards Bay have wondered a little at this line. "What happened to Penikese in the hurricane of 1937?" I asked a local authority. He answered, "One of the hills was washed away."

Looking back over the seventy intervening years we realize that Agassiz started all the summer schools that ever since have flourished independently and in connection with the colleges in all parts of the country. Now it seems likely that for the most part they will become the summer sessions of the universities, a worthy culmination for a notable movement in American education. We realize also that the scientific method taught by Agassiz is now followed in all schools. In his struggle against ignorance and prejudiced conservatism Agassiz has triumphed.

High on the façade of Stanford University Dr. Jordan placed the statue of Louis Agassiz. He stands facing the east, where the dawn breaks over the foothills.

⁸ Jordan, *Days of a Man*, Vol. I, p. 118.

ANOMALIES IN COLOR VISION

By Dr. ELSIE MURRAY

DEPARTMENT OF PSYCHOLOGY, CORNELL UNIVERSITY

HUNDREDS of young men eager to play their part in the great drama of the sea and air have struck unexpected hurdles in the office of the medical examiner, emerging with the disqualifying verdict, "color-blind." In vain they protest that they can see colors as well as the next one, that there are no gaps in their rainbows. Many of the rejects affirm further that they have no difficulty in distinguishing red from green, are never bothered by traffic lights. Obviously, they assert, the tests are unfair.

No, they are not unfair, as such things go, in the best of *possible* worlds. Severe they are, however; and indeed at the present hour they need to be. Misreading of a signal at dusk, in the rain or at a distance, in the face of the enemy, might mean the crash of a bomber, the death of a whole ship's crew, the annihilation of a battalion.

Today's favorite screening test for color deviates is composed of small multicolored charts, such as those long ago devised by Stilling and Ishihara. Each chart contains one or more digits or letters formed of tiny colored dots and disks, on a differently pigmented ground, discernible or not according to the color sensitivity of the observer. These digit-mosaic charts, Franco-German in origin, with their later Japanese, Russian and French variants, are known to the specialist as *pseudo-isochromatic*. Digit and ground are made up of carefully selected "confusion colors," producing on the anomalous eye the illusion of identity, and causing the digit or letter to disappear in the ground.

Such tests utilize the fact that so-called "color-blindness" is not blindness to color, but loss or weakening of certain sensory responses, automatically reduc-

ing the number of discernible color differences. Red and green are most commonly affected. When these drop out—together, as they usually do—the differences between digit and ground, readily perceived by the color-capable, are obliterated. The entire field may turn to grey; or, in the case of a violet digit on a blue ground, the whole array of dots and disks may appear in tones of blue, through fading of the red component of the violet. Either change renders the digit invisible or illegible.

In their present form, the charts admittedly are not analytic. They are keyed to spot *average anomaly*, plus one variant only: the rare form due to shortening of the red end of the spectrum (scoterythrous vision, sometimes ambiguously termed protanopic). They are not designed to diagnose or classify the vast number of deviations from the typical, many perhaps semi-pathological, known as *borderline cases*. They do not even clearly segregate color-blind from color-weak. Many clinicians ignore this, however, accepting the set of charts unthinkingly, as the average man does his radio, or a Solomon Islander might a motor, with no concern as to the inner principles of its operation.

Unquestionably, the tests now in vogue are more severe than the old wool-sorting ones of Holmgren, evolved long ago for the selection of railroad engineers. The latter, utilizing wool skeins instead of a printed mosaic, offer larger masses of solid color of high chroma, over which the eye can travel freely. Matching or sorting these at a lesser distance, the examinee with a central scotoma (color-blind area), or a retina pock-marked all over with scotomata (minute insensitive points), or even a high degree of red-

green weakness can make a passing score. The digit-mosaic, or "vanishing pattern," test, on the other hand, though far from perfect, if administered by an expert, under standardized conditions, with vision corrected for refractive errors and deception barred, does the job more efficiently than any wool test—Holmgren, Jennings, Nela. Its rejects actually are dangerous cases, with color vision unequal to today's exacting military tasks. In all but highly favorable and stereotyped situations, they carry on under a definite handicap. In emergencies they constitute a definite liability for comrades and commander.

Why, then, is it that the diagnosis of disability comes as a shock to the examinee, who was not born yesterday? Why are protests so common? There are many reasons, and it is high time that science undertook to clarify them for the general public.

First of all, one must admit that protest is in a measure justifiable. The term *color-blind* is a misnomer. The fraction of cases who see the world in tones of grey—a Turner or Matisse, as it were, in a black-and-white or half-tone cut—is negligible, and semipathological. The American vogue for streamlined, abbreviated phrases works against the substitution of "color anomalous"—six-syllabled instead of three, and evoking vague visions of Harlem, of epidermal as well as retinal deviation. A concise color vision variant (C.V.V.) would fit the facts more nearly, in the opinion of the writer.

The older term, even when qualified by *partial* or *red-green*, as already hinted, is misleading. The average reject is not blind to color. The photo-receptors in his retina respond as a rule to all color stimuli, including those linked with the very sense qualities lacking in anomalous vision, red and green. He has merely reverted, as it were, to a simpler type of eye, sensitive to all light frequencies, but reporting them in terms of a single pair

of qualities, blue and yellow. Science terms this, not blindness, but a *reduction system*. (Occasional shortening of either end of the spectrum does occur, but whether due to insensitivity or to absorption of light waves in transit to the receptors is a point unsettled.)

A second source of grievance centers in the failure of current pseudo-isochromatic charts to segregate degrees of disability, *color blindness* from *color weakness*. All who fail on three or more charts are usually thrown out together. As a matter of fact, to this day no one knows whether or not all gradations of color sensitivity from normal to red-green blindness and on to achromatopsia (loss of all color qualities) occur. Test results claiming to settle the point run back over a hundred years; but doubt arises as to whether the scatter is due to technique and method or to individual differences in color thresholds.

Some of the loudest protestants against the army and navy test diagnosis fall undoubtedly in this intermediate class, termed by Von Kries "anomalous trichromates" (with several other syllables agglutinatively added). Their red is probably a reddish orange, their green bluish or greyish, their color fields restricted. At dusk, in rain or fog, their weakened red-green color pair is likely to fail them. They are subject to rapid color fatigue, and are likely to see vivid complementary color halos amounting to illusion on the neutral background of small color fields. While they can "get by" in the majority of everyday situations, can even handle technical color work with certain precautions, they are virtually color blind in slightly unfavorable or unusual circumstances, and consequently are possible sources of danger. The writer has yet to contact an experienced military officer who would care to risk them in his entourage.

As for the red-green blind who lacks entirely this pair of sense responses, his obstinate denial of disability stems from

various sources. Unwillingness to admit defeat is universal, *vide* the vast literature of inferiority complexes. Each of us, moreover, is confined in his own sense world. The anomalous-visioned has no eyes but his own to see with, no standards but his own to judge by, no more notion of the sense quality he lacks than the layman has of the fourth dimension. As the traveller in Arabia acquires perforce a few Arabic phrases, he experiments with his color-capable neighbor's vocabulary, and often achieves a modest success. Mistaking brightness and vividness gradations in the yellow region of his spectrum for greens and reds, he obstinately insists that his repertoire of colors is as complete as his neighbor's.

This fixed obsession of many color-blinds and color-weakens that their buffs and tans and browns are unique hues, identical with the greens and reds of everyday speech, finds an analogue in the behavior of certain normals. Untrained in color terminology, ignorant of the permutations through which a single hue may pass by darkening and dulling, when asked to sort fifty color samples by hue the color-capable not infrequently refuses to throw buffs and tans and browns in with yellows or oranges. These country cousins of the more gorgeous hues, he insists, are something apart, unique, deserving of two extra piles or compartments. The existence of specific color names, such as tan and brown, is cited in evidence. Only careful study of the constant-hue pages of the "Munsell Manual of Color" will convince him otherwise.

Use of his neighbor's color terms correctly in perhaps fifty per cent. of cases often camouflages color disability in the deviate's social circle. Early family incidents, it is true, may break through this verbal guard, especially in country districts. The lad who can not see the proverbial cherries on the tree a rod or so away, or detect the pink flush on the cheek of a ripening peach or apple, has it driven home that his vision is unique,

and learns to his sorrow that no oculist can better it. The hunter who fails to sight the red squirrel or partridge in the autumn woods, or mistakes the red coat of a comrade for the tawny one of a buck, learns his lesson also.

A younger sister's jibes at eccentric color combinations—a red sweater worn with purple socks, a violet necktie with a bright blue shirt—are also effective in opening the eyes if not in improving the taste or vision of their target. Yet often these early warnings slide off like the proverbial water from a duck's back, leaving their recipient placid in the belief that colors and color names are purely feminine preoccupations, which any male could master if he put his mind to it. In the 30's and 40's, to be sure, when colored inks began to invade the masculine precincts of printing and advertising, neon lights to transform quiet thoroughfares into garish midways, and even bathrooms and kitchens put a strain on the color eye of the plumber, the male and especially the color-blind began to be color-conscious.

Few college students now get past the medical office without some intimation of their status. Sceptics are apt to be tripped later in the psychology classroom as they match yellow skeins with pink to the delight of their color-capable fellows. In order to drive the point home, fraternity brothers have been known to consign expensive but gaudy outfits to the lock-box. Many still persist, however, in referring their idiosyncrasies to taste and interest rather than deficient sense equipment. Ability to read recent faultily printed and valueless pirated editions of the digit test helps confirm them in this attitude; as does also the fact that the reds and greens most damaged in deficiency are not the typical reds and greens of flame and foliage, but a certain crimson and verdigris of a bluish cast. (Of this more later.)

At this point the sceptical will propound a riddle. If no notion of the visual world of the normal-eyed is pos-

sible to the color deviate, how can science hope conversely to penetrate the half-world of the latter? Nature has obligingly furnished the normal eye with certain cues, with the aid of which the color specialist can construct the color world of his undervisioned brother, much as the paleontologist evolves a mastodon from a molar. One such cue is furnished by the color-changes hues undergo when passing into the marginal fields of vision. For the normal eye is completely color-capable only at the center. Between this and the outer totally color-blind zone is a middle region of partial or red-green blindness. Test this by drawing small bits of colored paper (red or green or orange) away from a central point of fixation and you discover that when red and green fade out *blue and yellow* take over.

Combining this cue from indirect vision with the testimony of monocular color-blinds, we gather that where the normal sees green in the spectrum the red-green blind sees tan or fawn or sand—a dulled yellow. "Sand" becomes stand-in for green, appropriates its name, gets accepted as a unique hue—the color of grass and foliage. The verbal tag "red" attaches itself in like fashion to the golden brown that dominates the long-wave end of the color deviate's spectrum. Through association, these terms may then be used correctly in a surprising number of cases. Often, however, a mere passing shadow on a colored surface, or a stray sunbeam, is sufficient to alter the judgment of the color deficient from green to red or vice versa. Certain tones of yellowish red and yellowish green are, indeed, indistinguishable (confusion colors). Hence combinations of these are avoided in up-to-date traffic light systems, a *bluish* green doing duty as a "Go" signal with a scarlet or yellowish red for "Stop."

This translation of the visual world of the partially color-blind into tones of blue and yellow was early described by discerning members of the group. Rare

and interesting cases where one eye was normal, the other color-deficient, or where color disability was acquired at maturity or later, confirm the earlier accounts. Laboratory matches of one portion of the spectrum against another complete the story. The accumulated evidence, admirably summarized in 1925 by Drs. Mary Collins and James Drever of the University of Edinburgh laboratory, shows conclusively that the majority of cases stigmatized as "color blind" by examiners are *not blind to color stimuli*.

Though the color deviate's retina responds to about the same range of light stimuli as the normal's, i.e., wavelengths of 390 to 780 millimicrons, the number of colors sensed as different is reduced. Of the 150 hues seen in the vividest band of colors by picked observers—of the blues, indigos and violets, the leaf-greens, emeralds and peacocks, the golden and greenish yellows, the scarlets, oranges and crimsons—the red-green-blind retina discriminates surely just two, the blue and yellow above mentioned. (So the famous chemist Dalton long ago assured us.) Hence the color palette of the *dichromate* (so science dubs the typical undervisioned) is tremendously restricted. Instead of the millions of permutations and commutations of the 150 hues with light and shade, he has only thousands or possibly hundreds in his repertoire of color.

To one who has never been a millionaire an income running into four places is not despicable. But had the color world of *Homo sapiens* never developed beyond that of the dichromate, the voluminous dictionaries of color and color terms (Maertz and Paul's and Munsell's) would never have been evolved. Nor would an elaborate color solid formed of two pyramids base to base on a central black-white axis, every fragment of its surface under successive strippings unlike every other, be needed to figure compactly your color world and mine.

A mere plane section of this elaborate figure suffices to display the diminished color capital of the dichromate. For the rare case of complete color-blindness, the black-white axis (with grey intermediates) alone is needed. The visual world of this unfortunate is to ours as an engraving of a landscape or a portrait is to a Raphael or Childe Hassam original.

Brief reference to physiological theory may illumine further the enigma of color blindness. Laboratory techniques demonstrate a complex and variegated apparatus of rods and cones and nerve structures in the minute microscopic tissues of the retina (the latest word on which is offered by Polyak's "The Retina"). Parsimonious science, however, needing every pinpoint of the retinal mosaic for space perception, refuses to allocate separate elements to each of the numerous hues of the color pyramid. Instead, she factors her continuum of 150 hues into four primaries, to each of which is allotted proprietary rights in certain nervous structures; combinations of these four provide intermediates.

Choice of the four primaries is dictated by certain observations. The position of the grey bands in the low-intensity spectrum of the color blind—near 500 m μ (a faintly bluish green), and toward the long-wave end (a slightly-bluish red)—affords the first cue. The stability of certain hues under altered light intensity offers another; and the identity of the four thus chalked up with those that in the marginal fields either do not alter (blue and yellow), or that pass without change into grey, clinches the matter. Inductive science therefore picks as her four basic hues crimson and verdigris, blue (slightly purplish) and golden yellow.

These four, thus inductively determined, turn out to be two sets of true complementaries, linked in pairs by still other visual phenomena, negative after-images, contrast halos, and the fact that

they neutralize each other on the color-wheel. The pairs so linked are blue and yellow, crimson and verdigris. In ordinary red-green blindness, the last-named pair is the one affected—the one most likely to lose all color tone with low illuminations. Various interesting explanations of this linkage, chemical, physical and histological, are available.

The fact that the two primaries thus singled out by the finger of nature as less stable are not the typical scarlet of the poppy or the yellowish green of grass, which perhaps come first to mind with the words *red* and *green*, adds to the sum of grievances of the unfortunate red-green blind. For the reds and greens of everyday speech, as already mentioned, are effective stimuli for the yellow sense apparatus, appearing as browns and tans in severe cases, as oranges and olives in mild cases (the merely color-weak). In like fashion, very bluish crimsons and greens may be seen as dull blues through the action of the reflected light waves on the blue sense-apparatus.

One hopeful corollary of this is that the world of the color blind is not all dun and drab. He is usually quite blue-yellow capable.¹ Bluebells and daffodils, wild asters and goldenrod, blue eyes and blond locks, chicory in the ripe wheat, lose no whit of their appeal. The glory of a Titian-hued coiffure is, however, wasted on him. A color-deficient husband is reported to have described the hair of his red-headed wife as "lacking in pigment." Lipstick preparations may call out similar verdicts, though a number are easily confusable with grass-greens.

At this point we may profitably follow the lead of the notable nineteenth century Dutch ophthalmologist, Donders, who had recourse to evolutionary theory. In many of the lower animal species the

¹ In a rare form of color deficiency, blue-yellow blindness, the residual hues are red and green.

discrimination of colors—of greens from blues, reds from browns or greys of equivalent brightness—is strictly limited. Various orders, of which the domestic horse, dog and cat are members, display, in short, the equivalents of partial or total color-blindness. Hence Donders and his successors attributed to the earliest type of eye black-white-grey perceptions only. Blue-yellow apparatus for daylight vision, linked with the retinal cones, followed next, perhaps in a primitive lemur, perhaps in an early primate. These two hues, blue and yellow, shared the spectrum at the start, one taking over the short, the other the long wavelengths, "licking the platter clean" between them. Their cones drove the rods, organs of black-white night vision, out toward the edge of the retina (hence to see a faint star you must view it out of the corner of your eye). The crimson-verdigris (or red-green) sensory pair came on the ground late, insecure interlopers, hunting a place in the sun, encroaching on their predecessors without displacing them. Never gaining *entrée* to more than a restricted central field, never setting up exclusive claim to any wavelength of light, they are the first to go down under pressure, e.g., in congenital or acquired color-blindness.

This evolutionary view, with slight distortions, was popularized by the late Ladd-Franklin, who attempted also a *rapprochement* between the color theories of physiologist and physicist. For, unfortunately, the formal mathematical approach of the latter, his color-mixture formulas and "as ifs," sometimes mistaken for fact in the field of color perception, have so far operated to paralyze rather than promote research in the field of color-blindness. Much of the present backwardness in the designing of tests must indeed be laid at the door of the physicist; for in the last analysis he is the apparatus builder on whom all science is more or less dependent; and un-

fortunately he is more apt in designing optical apparatus of his own, e.g., the trichromatic colorimeter, than in studying Nature's models, in animal and human.

Since the dawn of history, it appears, the number three has intrigued philosophers, theologians and some physicists, exerting a benumbing spell on the reflective faculties. Triangles, trefoil, trinities of all sorts have found little to oppose their *führership*. Obviously, the triangle is simpler than the square, and tables of three coefficients not only more economical to print, but easier to prepare and manipulate than those of four or more. Apparatus with three variants only is likewise simpler to handle.

And did not Aristotle himself remark that all things have a beginning, a middle and an end? Why not the spectrum? Even the wise Helmholtz was beguiled for a season into fitting the facts of color vision and color-blindness to a three-fold Procrustean frame, taking red, green and violet as his sole primaries. Some of his too zealous followers perpetuated the triple scheme he presently rejected in the terms *protanopia*, *deutanopia* and *tritanopia*. Protanopia is by definition lack of the *first* primary, red (blindness to long wavelengths of light); deutanopia, blindness to the *second*, green; tritanopia, lack of the *third* sense quality, violet (blindness to short wavelengths). It matters little to the Helmholtz enthusiast that the three types as defined are non-existent (a fact the old scientist himself appears to have discovered). Modern disciples go blithely on their way, evolving yellow preposterously from red and green, white from a fusion of red, green and violet—elaborating and complicating hypotheses in the vain effort to herd the vagaries of color vision and the known facts of color-blindness under the aegis of the sacred trinity.

Near matches acceptable to commerce (though not to observational science) are

obtainable by triple primary methods, tables and apparatus, which thus fulfill a definite function in maintaining standards in dyes, drugs and agriculture. Evolution of a spectrophotometer which analyzes light reflected from a given sample into a continuous curve, doing justice to intermediate wavelengths, promises better than the old tri-stimulus colorimeters, with their "dominant wavelength" telling too little of the actual look to the eye of a sample under average daylight.

Unhappily, however, the mathematical "as ifs" and hypothetical types of disability of the physicist constitute definite stumbling-blocks in the way of penetrating the plight of the color-anomalous. Nature *might* have made an eye on the triplex pattern, indeed she may have in the case of birds and reptiles, with three oil-drop color filters. But she appears to have discarded this design in the case of man (so we interpret the latest findings of Gordon Walls in "Visual Mechanisms" and "The Vertebrate Eye"). As long ago as 1932, moreover, the eminent authority on physical optics, R. A. Houstoun, of the University of Glasgow, in his "Vision and Color Vision" declared the Young-Helmholtz theory "mathematically untenable," "a violation of common sense," and a failure in classifying cases of color blindness. Even the editors of the third edition of the "Physiologische Optik" thought best to discard or alter Young's original schema of defect. Yet in the backwaters of academic classrooms it still lifts its head, to the confusion of the student. For regrettably no explanation of the visual phenomena of color-blindness at all serviceable to the layman has yet evolved from trichromatic theory.

Turning from physics to genetics, we find a new set of riddles in the incidence of color anomaly in the population. Partial or red-green blindness (the ordinary type, attended in some cases by

darkening of the red end of the spectrum) tends to run in families. It may affect two or more brothers, rarely a sister, eugenists tell us. Search into pedigrees often reveals a grandfather, usually on the maternal side, similarly afflicted. The charts in Julia Bell's "Anomalies and Diseases of the Eye" (in the *Treasury of Human Inheritance* for 1933) show that partial color disability follows the Mendelian pattern fairly closely. Thomas Hunt Morgan, the geneticist, classes it with haemophilia as a sex-linked or recessive trait, associated with absence of an element in a chromosome.² A color-blind man's daughter, though color-normal herself, may transmit disability to her sons. To prove this point, many pedigrees have been compiled; but the facts do not always fit the theory. It appears that red-green blindness may be incomplete (as already intimated); that there are half-way cases, retaining some red and green sensation under adequate stimulation. The woman carrier of the defect may prove to be such a case when analytically tested.

Both types, color-blindness and color-weakness, may be either congenital, or acquired through the use of drugs, infection or pathological nerve conditions. For more than a hundred years science has worried over the deviations from type, the borderline cases. Whether they are due to retinal deficiency, or to pigments in other of the eye tissues that block the passage of certain rays, such as yellowish green in the lens or cornea, is a moot question. Adequate tests to assay these deviations have yet to be devised—but a friendly warning is in order. It is not worth while arguing with anyone over the precise color of a gown or a cravat. The chances are two to one or better that each pair of eyes

² Merely recessive, apparently, in total color blindness (achromatopsia) and its borderline forms, which affect women almost as often as men.

sees them differently. Acquired cases, due to the excessive use of alcohol or tobacco, or to systemic toxins, are probably also more frequent than was formerly supposed.

Of the handicap of color disability, complete or incomplete, in military operations on sea or land or in the air, there can obviously be little question. Not only is confusion likely to arise in critical moments, in mist or smoke or fog, obscuring signals, veiling enemy approach or camouflage, but the color-sensitive zones of the eye are narrowed, and color signals in the marginal field may be overlooked. Perception of perspective, judgment of distance and contour is likewise subtly disabled by lack of color-toned shadows. Experience shows that color-blind aviation students are not only handicapped in the choice of a landing (ploughed field and forest being similarly toned); they are apt to fumble in any visually regulated setting down of a plane.

Granted a handicap affecting four to ten per cent. of the male population, speculation as to remedial measures at once arises. Myopia can be corrected with lenses, heterophoria with exercises. What of color-blindness or weakness? Publicity of late has centered on the discovery by Wald and others of vitamin A in the chemical cycle of rhodopsin or visual purple (the photo-sensitive substance linked with night vision). Heavy dosage with vitamin preparations, or with liver or codliver oil, has been experimentally studied, and in many cases lowered thresholds in the retinal rods (the receptors active in faint vision) have resulted.

Somewhat rash inference that color thresholds in the cones, the organs of color vision, are lowered also (the first test case was one of alcoholic cirrhosis of the liver) has led would-be benefactors or notoriety seekers to experiment with high dosage of men who were failing in

army color-tests. The results so far are ambiguous with no guarantee of the permanence of improvement. The sensory apparatus for night vision and for daylight or color vision has long been recognized as twofold. No sensitizing or sensitive substance in the cones linked with color vision, as the visual purple of the rods is to light perception, has yet been isolated in man. The chance that it is a carotenoid with vitamin A in its cycle is relatively slight, though some evidence points toward a visual violet. Acquired, or pathological, cases of color-weakness, it is true, might be kept at higher levels of efficiency by heavy vitamin dosage. But until reserves run low, what use has Uncle Sam for a submarine captain or a commando dependent on a pocketful of pellets? Meanwhile nutritionists and white-ribboners are capitalizing on the situation. If color vision can not be improved, they argue, it should at least be guarded from deterioration.

A certain measure of consolation may be meted out to the reject whose hopes of cure are dissipated. His case is not unique. One out of every ten or so of his fellows is in the same predicament. He has, moreover, distinguished company, past and present. Color vision anomaly was first called to the attention of science a century and a half ago by a famous chemist, Dalton. (He was a Quaker and is said to have scandalized the congregation by wearing scarlet hose to meetings.) Today, in every college faculty there are several cases, usually in mathematics—a safely neutral subject. Engineers, architects and metal workers account for additional per cents.

Those who have chosen a vocation incompatible with defective color vision, and now discover themselves in the wrong pew are less consolable: the florist, the dyer, the drygoodsman, the color photographer, the make-up artist, the theatrical producer—or the plumber. Chemist or physician can often be fitted

by expert oculists with polarizing lenses or colored filters which, though they can not restore the missing hue to vision, may by bleaching or darkening enable the wearer to detect its presence in certain cases.³ Novelists may go blithely on their way, using color terms in conventional fashion—witness Ben Ames Williams and his annual output. Artists can get along with labelled tubes, though sudden discovery of the handicap may precipitate a nervous breakdown. It is, by the way, a favorite theory of the writer that the recent vogue for daring color combinations was launched unwittingly by some color-blind artist, with never a notion that his visual world was unique, or his canvas other than two-hued. For no color discords exist for the dichromate—his eye paints everything in harmonizing complementaries—if our postulates are not all awry.

With the progress of science, other perspectives and vocations may open up. Many interesting problems, the solution of which would benefit the entire fraternity of the undervisioned, are yet untouched. Among the anomalies there may well be eyes supersensitive (as well as subsensitive) to certain colors, the fitting allocation of whom in the world of tomorrow awaits discovery. Racial differences harking far back in evolutionary history may come to light when appropriate tests are adopted. Research biologists, George Wald of the Harvard laboratories among them, tell us the two types of retinal carotenoids associated with vision in deep-sea and fresh-water fishes persist long after a species has forsaken its ancestral environment, except for spawning (*vide* the eel and salmon). It is possible that some human beings inherit the equivalent rhodopsin, some the porphyropsin of these lower vertebrates, with corresponding shifts in sensitivity to light and color. Among

³ Practise with colors does little to speed up the slow color reactions of the color-weak.

the borderline cases there may be atavistic eyes, eyes strictly nocturnal and eyes diurnal, as distinct from the twenty-four-hour duplex mechanism most of us inherit. From the mass of rejects, cases may be sifted out uniquely fitted for submarine, destroyer or airplane service. The red-weak (protanope of the physicist) may be jungle-eyed, best suited for twilight vision; the blue-weak, eagle-eyed, best adapted for desert action.

Our present tests for the most part are not diagnostic, merely separating out safe from unsafe relative to a conventional situation. Some evidence is already available, however, to show that Mediterranean, desert and atoll-island people are blue-weak, with diurnal vision dominant, an eye protected from ultraviolet rays by yellow-pigmented tissues. In like fashion, red-weakness may stem from forest and jungle races, or people of the foggy northlands, with eyes adapted to twilight vision.

Instead of raging against fate, or the Japanese and German tests which are still the main stock-in-trade of the examiners, one wonders why no disappointed reject has thought to organize his fellows. Anecdote and jest at discordant-hued cravat and hose, at nonchalant slipping past urban red lights dimmed to slim four-armed crosses, lose their sting when all are equally exposed to the shafts of wit. A mass of interesting data could be assembled, the matter of heredity reconnoitered, the feasibility of prenatal treatments laid before the medical profession, cases of acquired deficiency explored. Pressure might even be brought to bear upon examiners to write "color-anomalous" rather than "color-blind" across vocational scorecards.

We suggest that, when the war is over and our boys have emerged from the jungles and the deserts and come up from the bottom of the sea and when the problems of the Axis-ridden peoples of

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Europe, Asia and the islands of the Pacific have been temporarily adjusted, our scientists get together on the plight of this tenth of our own male population. All-American tests need to be devised, compulsory in the lower grades of the public schools and at graduation. The examined should be provided not with a blanket verdict "color-blind" nor even with a single color quotient, but with a *color profile*, showing at a glance daylight ability relative to the average in

half a dozen hues; starlight and total blackout sensitivity also.

Meanwhile those of us who are color-capable may well devote an occasional moment to mentally recasting the world about us—aswarm with traffic lights and neon signs, gay with war-motivated scarlet costumes, aglow with florists' windows and tropical flowers, or lit up with autumn foliage—into the two-hue system of the dichromate, blues and yellows—a partial color dim-out.

THE CALLAO PAINTER

By Dr. ELIOT G. MEARS

PROFESSOR OF GEOGRAPHY AND INTERNATIONAL TRADE, STANFORD UNIVERSITY

AT times, the inhabitants of Lima's seaport remark, in their native Spanish, that "the seawater is sick, for it stinks." Simultaneously, they experience distressing headaches, the silver in their houses tarnishes, and the old paint on their fishing craft inshore becomes discolored. This marine phenomenon, which has an established history, has received scant notice in scientific journals. Locally it is known as "aguaje," less frequently as "agua enferma." Leading Spanish dictionaries fail to define these expressions according to their local usage. The name most used internationally may be said to be the "Callao Painter," so called after its marked distinction in blackening white and other light-colored boats in the Bay of Callao (lat. 12° S).

The manifestations are well known and fairly regular in occurrence. At undetermined intervals, but frequently during the Southern Hemisphere's summer and early fall, the Peruvian seacoast from approximately Paita (5° 05' S) to Pisco (13° 43' S) experiences a marked turbidity of the sea accompanied by the strong emission of hydrogen sulphide. Enormous quantities of dead plankton float about and line the shore. Guano

birds die by the thousands. These striking transformations are normally associated with the invasion of warm water from the Equator into the cold Humboldt or Peru Coastal Current. Sudden and marked sea and land temperature changes are conspicuous; to many persons, these meteorological variations are a sufficient explanation. Yet the underlying reasons for the "Callao Painter" are still undetermined owing to the fragmentary physical and biological oceanographic data. The causes are likely to be found in more than one field of investigation carried on in this unique Pacific South American region.

According to tradition, submarine volcanic action has been alleged to be the real cause. Doubtless the unsettled mass formations, including frequent earthquakes, did provide a ready answer. But there has come to light no worthwhile evidence, based upon scientific investigation, why the oceanic area associated with the Humboldt or Peru Coastal Current should account for such local disturbances. The presence of a volcanic rim around the Pacific does not help us materially towards a solution. The "aguaje" is conspicuous in protected

bays where the local eddies and currents appear to accentuate the situation. We are justified, however, in discarding the early hypothesis.

A number of other explanations have been offered. They merit notation, even though they can not be discussed at length. For example, it is well known that many forms of cool water life can not be maintained in the presence of warm water. For, when warm currents appear in such an area, maladies occur and deaths ensue in proportion to the contrasting temperature of the trespassing current or eddy with that of the Humboldt Current. This fact might seem adequate here; but if so, how can we account for the proven incidence of illness, in the year 1925, before the invasion of the warm current? That is one of the mysteries which requires further study.

Again, why should warm oceanic water, which ordinarily avoids the cold Peruvian current, measuring as it does from 2500 to 3000 miles long and from 100 to 250 miles wide, occasionally or periodically flow across or replace it? Several hypotheses have been advanced, notably by E. W. Barlow, of the British Meteorological Office, who, in summarizing the observations in 1939 of the Volunteer Merchant Fleet of 923 ships, found that even the strongest currents have reverse sets. For instance, the steadiest stream in the South Pacific, the South Equatorial Current, has many eastward sets during the southern summer when it is weakest, and at any time in the year such a current may be met occasionally.

The Peru Coastal or Humboldt Current receives its most severe reverse sets in summer also, but it may have inshore or southward moving currents in winter, when it is at its greatest strength. However, the reverse sets in the Humboldt Current are often warmer than the usual waters—observations which are not true of the South Equatorial Current.

The most careful survey of the Humboldt Current was made by the *William Scoresby*, from May to September of 1931, and was reported by E. R. Gunther who found a southward moving, subsurface current of subtropical water always present directly beneath the sub-Antarctic, northward moving water layer. He interpreted this as a return current of compensation which should have flowed at the surface, were it not for the northward movement of the less saline, and therefore lighter, subantarctic water of the Humboldt Current. At Antofagasta, Gunther noted on one occasion that strong upwelling had drawn this subsurface return current to the surface; and again, at San Juan, the current was at the surface and was sufficiently strong to push the motor ship backwards against a stout southerly wind. Gunther did not venture an opinion other than upwelling as to how this current happened to be at the surface.

H. U. Sverdrup, of the Scripps Institution of Oceanography at La Jolla, has called attention to a similar subsurface counter flow under the California Current during its period of upwelling, when it is a "mirror image" of the Humboldt Current. When upwelling ceases in the California Current, the subsurface return current rises to the surface and continues its course, both as a surface and as a subsurface current. It appears likely that this is exactly what the return subsurface current does under the Humboldt Current, for, in a given location, when the upwelling becomes less active or ceases entirely, the return current tends to rise to the surface.

Since it has been proven that the return current is poor in oxygen content its rise to the surface may menace the life in the surface layer accustomed to a habitat rich in oxygen. Thus, strong upwelling without sufficient aeration could prove disastrous, as well as a rapid rise

of the current due to ceasing of upwelling.

The area from which the return current appears to stem has less than ten per cent. oxygen content; its location is in the equatorial belt at depths of 200 and 800 meters, extending from Panama to the vicinity of the Galapagos Islands. Besides, it is known that the subsurface current under the Benguela Current off West Africa, which has much in common with the Humboldt Current, is exceedingly low in oxygen value. The only station where oxygen records are available, as indicating the content of the Humboldt's subsurface layer, shows a lower oxygen percentage than that of the Benguela Current. How poor in oxygen the return current of the Humboldt region is has not been reported. It is thought that this low oxygen value in subsurface water under the Benguela Current is owing to the enormous amount used up in the process of decay of the vast bulk of vegetable and animal remains constantly falling from the surface through the lower layers. Since there is no evidence to indicate that the life in the Humboldt Current is less than that in the Benguela (the contrary is far more likely), Sverdrup is of the belief that perhaps the subsurface waters under the Humboldt Current are very poor in oxygen also. G. E. R. Deacon, of the British Discovery Committee, found in the far South Pacific that the return current layer had the properties of water that had long been removed from contact with the air; this would mean, among other features, that it is poor in oxygen content. If it is true that the subsurface current under the Humboldt Current is very low in oxygen, and Gunther frequently noted that upwelling came from this layer, the cause for the "Callao Painter" is never far removed from its oxygen-rich surface waters. But whether or not the subsurface return-current has a dangerously poor oxygen content remains unknown.

However, anything that would cause destruction to the life of the Humboldt Current would, also, produce hydrogen sulphide from the resulting decay. Temperature forms a very definite barrier to many life species. In 1941, for instance, M. J. Lobell, of the U. S. Fish and Wildlife Service, noticed that tuna fish in the Humboldt Current area not only retreated with the warm waters but died if caught in waters below seventeen degrees centigrade (62.6° F); on the other hand, anchovies thrived in lower water temperature. Therefore, any warm water invasion into this cool water area results in the migration of various cool water species and the death of many others. It may be said that warm water wedges or counter currents are at least one cause of the "Callao Painter." A number of factors have been suggested as producing these eddies and counter currents.

The most famous of the invading currents is that from the north, supposed to be a branch of the Equatorial Counter Current, which takes a southward turn during the strong northerly winds of the northern winter, at a time when the Counter Current is weakest. Its annual infringement upon the normal preserves of the Humboldt Current occurs about Christmas time or shortly thereafter, and is for that reason called *El Niño*, for the Christ Child. Punta Aguja is its usual extreme southern limit, but in 1925 it was reported as far south as Valparaiso (33° S).

Lobell questioned whether the warm waters which reached from the north and west of Peru to northern Chile in 1941 were a tongue of *El Niño*; he did not believe that this was true south of Salaverry (8° 17' S). It seemed that the more southward waters were series of wedges from the warm open ocean to the westward; and they were similar to those warm water tongues noticed by Gunther in 1931. The warm water invasions of 1941 were much more severe than those

of 1931, for it was noted that thirty miles offshore, "dead birds littered the surface." Except for plankton, little mention was made of dead fish; the cool water fish, absent for the most part, were replaced by warm water forms. In 1941, decaying life produced pronounced evidence of the "Callao Painter."

Both E. H. Schweigger, of the Peruvian Fisheries Department, and M. J. Lobell agree that the warm water eddies of 1941 were accompanied and preceded by southerly winds with a westerly instead of a normal easterly component. Indeed, Schweigger has furnished strong evidence, based upon the records of sixteen years, to prove that upwelling tends to cease and westerly waters to invade the Humboldt Current when the predominance of the average wind direction shows a westerly component; winds with strong easterly component cause upwelling sufficiently powerful to hold back attempted westerly and even unusually large northerly invasions. In Schweigger's opinion, those from the north, attributed to *El Niño*, are caused by a southward shift of the equatorial, low atmospheric pressure.

There are other interesting observations and hypotheses. For example, Robert Cushman Murphy has noted that the Benguela Current and the Humboldt Current were affected similarly in 1925 by warm water invasions, followed by heavy rains and floods and by enormous destruction of marine life. He has stated, moreover, that the phenomena belong in the main to a seven year cycle, possibly connected with sunspots. Otto Pettersson, of the Hydrographic Station at Borneo, is confident that the explanation is to be found in the tidal forces operating on shelf ice in the Antarctic in the years immediately preceding the disturbances in the Humboldt Current; therefore, in Pettersson's opinion, the moon, and not the sun, is the chief factor to be observed pertaining to the northern invasions.

Gunther has suggested that the middle Peruvian warm water wedges might be due to a seiche, sometimes referred to as a stationary wave which is conditioned by the shape, length and depth of a basin's contour. According to H. A. Marmer, a seiche "may be found in any portion of the sea partly bounded by land, for any such area can sustain a stationary wave." Gunther claimed no knowledge of any seiche studies along the Eastern Pacific littoral. (It is interesting to know that the seiche movement in San Francisco Bay was determined precisely by Japanese scientists, who constructed years ago a tiny model of the bottom and sides of the bay, and then placed it in a pond; thus they were able to measure the exact rate and height of any wave in San Francisco Bay originating in the open ocean.)

Seiche studies off central Peru, however, are unknown to the writer, but there is a Milne Edwards Deep, which extends from near the northernmost part of Gunther's warm water wedge of 1931 to its southernmost part, with its deepest portion close to Callao. During the same year, Gunther describes another warm water wedge along the line of deeps in the vicinity south of San Juan. Other investigators affirm that warm wedge invasions in these localities are common occurrences.

If the subsurface return current be sufficiently stagnant or if there should be stagnant water on the bottom of some basins, which are not too deep for a local disturbance to bring poorly-oxygenated water to the surface in sufficient quantities to endanger surface water life, the seiche movements might enable the manufactured hydrogen sulphide to produce its effects immediately. That is what the "Callao Painter" appears to do when it is present. As already mentioned, in 1925 the sea birds began leaving or became ill before the warm water invasion arrived. This might be explained if a seiche movement were beginning to dis-

turb the strata in the sea before warm waters arrived. In the absence of further data, it is impossible to express even an opinion as to whether such a movement exists.

Scientists at La Jolla have found recently that "sulphate reducing bacteria are widely distributed in marine deposits" along the California and the Gulf of California coasts; in the diatomaceous muds of the latter vicinity, these oceanographers were able to calculate the rate of hydrogen sulphide production. Such bacterial studies in the examinations of the Humboldt Current area fail to exist, so far as the present writer can discover. But diatomaceous mud is the chief marine deposit throughout the length of the Humboldt Current, according to E. Neaverson of the British Discovery Committee. The depth range of these muds on the seafloor of the Humboldt Current extends from twenty-nine meters to more than 4000 meters; apparently, the difference in depth has no effect upon the character of the deposits. Neaverson made no mention of hydrogen sulphide formation.

Investigation in sewer systems have shown that the production of hydrogen sulphide in the waste becomes a nuisance only when the sulphate-splitting bacteria are not destroyed or, at least, not held in check. A treatment of the bacteria, and not the waste as such, removes the nuisance. If some chemical medication might be applied to the "Callao Painter," the decaying materials might perhaps become less injurious.

There is plenty of waste material in the Humboldt Current at times of major invasion of the area by warm currents, since that flow is unquestionably rich in marine life. The vast quantities of dead bodies inshore and within the harbors putrefy. In the process, the sulphate-splitting bacteria have a part; naturally, enormous amounts of hydrogen sulphide are produced. The greater the destruction of marine organisms, the more evi-

dent are the manifestations of the "Callao Painter."

Scientists and travellers alike are impressed with the vast abundance of life within the Humboldt Current. A census of the larger forms of life there has never been taken; perhaps this is impossible. Murphy finds, so far as birds are concerned, that the limits to their increase are not determined by the food supply, for a diminution of the latter has not been observed. Rather, the number of birds in this area has been curtailed by enemies and by available nesting places. With respect to fish, Schweigger has estimated that the guano birds alone remove some 5,500,000 tons per year from this current. Fishermen in normal times of cold water find no shortage.

A navigating lieutenant of the British Admiralty has been more specific. During his seven months' stay in Callao in 1882-83, an explosion occurred in that bay. So many fish were stunned that "the water was literally covered. Scarcely any under a pound were thought worth collecting, but the pile on our deck alone must have been about ten feet square and three feet high in the center. . . . A heavily laden boat was sent to the foreign man-of-war at Callao, and fishing craft off San Lorenzo were filled. Some private communication seemed to exist between San Lorenzo and the pelicans at Old Callao Point, a distance of about three miles; immediately, after the explosion a small number were seen advancing from there in Indian file, and in less than a quarter of an hour there was an unbroken line of these birds right across. . . . I fancy none went away empty."

Off the coast of Peru, Murphy has seen a formation of guanays in the morning take "four or five hours to pass a given point"; when they return in the evening, the white islands turn black with birds which are packed into "the borders of available standing room."

The plankton, upon which all other sea organisms depend, may range all the way from the jelly fish or crustaceans, upon which the largest whales of the open ocean feed, to the tiny, predatory insects on shipbottoms. Throughout large areas of ocean surfaces, a liter of seawater may contain no more than ten of these microscopic living particles. It may be a water desert. While in the Humboldt Current, the research ship *Ohio* in 1924 obtained a count of 1000 or more per liter at twenty-nine stations and as high as 200,000 per liter in one locality. A further serious gap in marine research, as W. E. Allen of La Jolla has demonstrated, is the unsolved problem of space relationships of plankton diatoms which can not be expressed mathematically, "because, at any given point in the sea, sinking may occur according to the formula to-day and not to-morrow, the difference being due to influences added, subtracted, or modified in ways not open to prediction."

Since much of the color of seawater is due to the plankton it contains, the nature and extent of the various colors provide probably a more exact measure of the plankton than would result from the inspection of a liter of water. For instance, diatoms are responsible for the characteristic green of the Humboldt Current, which is at least 2500 miles in length. In this general greenish tint, furthermore, other organisms, which vary in tones like the shadows among the clouds, lend their own particular hues to the different areas.

Gunther found many colors in the waters of the Humboldt Current, yet he added that the tints might not always be due to abundance of living organisms. "Off Pisco . . . the sea was colored

ochraceous-salmon, off Callao tawny olive and russet with patches of rusty brown foam, and off the Guanape Islands khaki. . . . Their occurrence at contiguous localities and nowhere else on the west coast, and their occurring where the warm wedge was converging with the coast is suggestive that they might have been forms of *aguaje*." This was especially true of the rusty colored foam, which was "reminiscent of Stiglick's remark that red *aguaje* may go away leaving the water frothy."

Johnson and Snook, in their researches on the California coast, have noted that "an aftermath of extensive outbreaks of red water is the decay of inconceivable numbers of microscopic bodies stranded upon the beach, causing very offensive odors, and poisoning the water sufficiently to kill animals such as sea cucumber crabs, and sometimes even fish, with the result that their bodies wash ashore and increase the stench." Similarly, in the Humboldt Current area, there is abundant evidence that the marked temperature features alone are sufficient to account for the migration, impairment or destruction of probably most cool water life.

Thus, two different research parties in different Pacific coastal waters, in both of which upwelling, eddies, and rich sea-life exist, noted a connection between red water in particular and an aftermath of stench and death of other sea life. These highly significant parallel findings merit further investigation.

The "Callao Painter" is a highly distinctive, marine phenomenon and mystery. Someday, the scientific reason or reasons for the "Callao Painter" will become known.

SOCIOLOGICAL EXCURSIONS OF BIOLOGISTS

By LEO KARTMAN

U. S. DEPARTMENT OF AGRICULTURE, BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

THE world at war has brought to a head certain very fundamental problems of economics, politics and general social dynamics. More than ever before the common man seeks to know the basic causes for world conflict and the essential reasons behind his own government's foreign policy and political line. Out of a welter of opinion and the tremendous profusion of editorializing in the daily newspapers and radio programs the average man has, at least, arrived at the point of understanding that the theory and practice of fascism derives from concepts which negate the very essence of scientific method and objective inquiry. We realize quite fully now that the corruption of fascist politics and economics has been hidden under the sensationalism of twisted biological theories of the "super race" which have been paraded through journals and books by the "scientific" apologists of totalitarianism.

Significantly enough, the world conflict has done more to clarify basic sociobiological questions than the meticulous data of a thousand technical papers. The findings of the natural sciences have usually been thought to be more "down to earth" and therefore more comprehensible to the average layman than the so-called social sciences which have been commonly thought of as being a hopeless muddle. But now we find that the reality of everyday experience is itself an integral part of the development of a scientific social science; it is that close contact with pressing, and oftentimes bitter, social problems that has taught the people much in the way of correct scientific thinking. One of the questions of early evolutionary theory, recently revived by fascist biologists, the existence

of so-called superior and inferior races of mankind, has been quite adequately negated by contemporary political and economic history. The people have, by and large, seen through the Aryan myth because of the very practices of fascism itself.

This brings us to the point of the present discussion. It is unfortunately true that certain scientists of democratic lands have written, in connection with biological ideas, particular conclusions which place fetters upon democratic action by their social implications. It is high time that biologists arrive at a political point of view that squares fully with the recorded factual evidence of modern scientific inquiry and with the objective methods of investigation by which those facts were discovered. It is time that the biology of society be based on a study of the human level and not upon laws which operate in the animal world.

It is especially important at this time, when we are in the midst of world conflict, that the historical, political, economic and ideological bases of the struggle be understood by the people. This necessity should make us doubly vigilant concerning our interpretations of social dynamics. We must be even on guard against any adumbrations which utilize Darwin's notion of the struggle for existence, for instance, as a justification for war, in general, on the grounds that this physical struggle is the "chief factor in human progress." Any statement by leading biologists which is not clear-cut in its meaning will be snatched up and utilized for reactionary political purposes by the sympathizers and active tools of fascism.

Certain well-known men of science have from time to time published articles of a more or less general nature concerning social problems in relation to biological concepts which have unfortunately given comfort to the now obsolete theories of social Darwinism. The superimposition of Darwinism and purely biological valuations upon the complex of social and political activity is a fundamental violation of scientific reasoning that has quite disastrous consequences in actual application. When we speak of the application of Darwinism or biological laws to society, in the narrow sense, we immediately become identified with a host of well-meaning (in most cases) but politically naïve scientists who unwittingly give aid and comfort to the "ideals" which the fascist ideology espouses.

Many of these workers in biological science are justly famous for brilliant research in various specialized fields. However, in the realm of sociological thought these scientists somehow divest themselves of the scientific method with which they live in the laboratory and cover their eyes with the nineteenth century spectacles of Herbert Spencer. They join in support of the Spencerian notion that social progress is the automatic outcome of evolutionary forces. Man, they insist, must not devise schemes and plans for social reform or directed mutation; meddling in the evolutionary process will only bring about disaster—let "Nature take its course." This is the type of thought characteristic of the modern descendants of the "Organicists," who devoted themselves to the mechanical comparison of human society to the structure and nature of biological organisms and their subservience to the "struggle for existence" and the "survival of the fittest."

At the present time we shall not enter into any detailed discussion of the organic fallacy so apparent in the bi-organismic theories of sociology. Here

we shall cite the words of certain contemporary scientists to show that this trend in thought, far from being buried, is as alive and kicking as ever.

Biological science, from the time of the publication of the *Origin of Species*, has given us countless factual evidences for the conclusion that man is not a "special creation" but has an organic and historic relation to other forms of animal life. This is a well-known and generally accepted postulate. Furthermore, this knowledge means that certain fundamental biological laws are applicable to human beings.¹ Does it follow that human organisms and their society are to be identified with other animals and zoological social forms because certain biological laws are applicable to both?

Evolutionary studies have shown that even the lowly Protozoa developed colonial forms in which there was already a differentiation of structure and function among the separate cells composing them. This specialization and differentiation was carried to great complexity in the whole line of evolutionary transformation. Shall we, on the basis of this fact, contend that human society is in reality an organism composed of specialized individuals who are completely dominated by those natural forces which determine the existence of other animals? Can we say, for example, that the dynamics of human life are to be identified with the social insects or the manifestations of "mutual aid" and gregarious habits in many zoological forms? Is it logical to assume that the applicability of laws, generalizations or formulae to a series of different objects reveals the identity of the nature of these objects?

¹ We may, for instance, seek detailed information regarding the types and quantities of acids in muscle during fatigue, the structure of neurons or histological changes induced by toxic principles. Obviously, a study of the organism as a whole, in its ecological sense, could not be profitably carried out by such methods.

We can, for instance, apply the laws of physics to a plant, an inclined plane, to man and to the flight of a golf ball. Does it follow that a man, a plant, an inclined plane and a golf ball are identical? It is true, of course, that human society is composed of individual organisms which are interdependent and whose activities represent a unity. Does this mean that human society is itself a biological organism, since even the lowest form of animal existence is a unity of mutually dependent individuals? A plant, inclined plane, man and a golf ball are all composed of atoms (or smaller physical units). Does it follow from this that all these objects have a similar structure and function and that their activity is a cogent manifestation of identical principles? Obviously, the answer to all these questions is a distinct negative. It is quite evident that this type of logical reasoning takes merely the trees into account while forgetting the existence of the wood. On the positive side such logic works in the direction of establishing a bio-sociological ontology which is, to say the least, a dangerous metaphysics that reduces scientific knowledge to the myths and fairy tales of medieval scholasticism so congenial to contemporary fascism.

Let us now take note of how certain scientists look at human society. Dr. Wm. E. Ritter, of the University of California, laments the circumstance that "... hardly anything is more unfortunate for modern culture and civilization than the very prevalent conception that human society is not natural in the same sense that hymenopterous or avian societies are natural."² In similar vein the famous entomologist and biologist, Professor V. L. Kellogg, can not accept the position "of those who persist in wishing and trying to look on them-

selves and human kind in general as of a different clay, endowed with a different breath, and existing in a different sphere from the rest of life."³

Professor C. M. Child, of Stanford University, admits that "human reactions are much more complex and varied than those involved in development and maintenance of hydroid or planarian pattern, or even of a human embryo. . . ." However, he can not explain this complexity, for its cause can not be found in biological phenomena as such, and so he finally concludes that they (human reactions) "are after all realizations of the same general potentialities of reaction and subject to similar limitations" as are the lowly hydroids and planarians.⁴

If human society were a biological entity, the individual would become merely an appendage of the organism carrying out certain specific and specialized functions as do the digestive cells of a sponge or the reproductive cells of a colonial protozoan. Here we have a concept which lends itself quite easily to the fascist philosophy of the dominance of the state and the submergence of the individual.

The eminent mathematician, Bertrand Russell, has recently urged that the motive force of human history is "the love of power" which is "the cause of the activities that are important in social affairs." Russell negates the very essence of scientific inquiry by his elevation of a metaphysical entity into the role of determiner of the sphere of real things; by his implication that the "love of power" stands as an absolute and indestructible *élan vital* above man throughout the most diverse forms of social history.

According to Russell, the antagonism between different social strata, such as capital and labor, is nothing more than

² Wm. E. Ritter, "Biological Basis of Social Problems," p. 169, in *Biological Symposia*. Ed. J. Cattell. Vol. II. Pt. III. Jaques Cattell Press, 1941.

³ V. L. Kellogg, *Atlantic Monthly*. June, 1921.

⁴ C. M. Child, in Cattell, *op. cit.*, p. 179.

a reflection of the universal and natural struggle for power even as "competition between organizations is analogous to competition between individual animals and plants, and can be viewed in a more or less Darwinian manner."⁵

To such investigators the development of human society apparently means nothing essentially new in natural history, for history itself is viewed as the outcome of certain ideas which have been operative and established from the beginning of time. Man is simply an animal in another skin obeying drives which were conceived in the very womb of celestial creation. Like Russell, a scientist at the University of California concludes that "the same general laws responsible for the origin of man have continued to operate on him."⁶

This theoretical approach to the meaning of history has completely lost sight of the real and distinctive nature of human society. Scientific inquiry has already shown that human culture (and the human individual taken in the sense of a complete personality) is a product of certain concrete historical circumstances. Man has been distinguished from the animals by a variety of attributes such as consciousness, religion, power of abstraction, power of speech, etc., but actually man differentiated himself from other animals in a fundamental way as soon as he began to produce his means of subsistence. In thus acting upon nature by means of his own physical organization he was at the same time creating the conditions of his material life and culture and creating a new level of existence with independent laws of its own.

Although most scientists agree that the increase or decline of population is to be found in economic and social causes, in some cases an unscientific bias seems to decide the way they interpret

the results of this process. We find that their conclusions are not primarily a discovery of the causes and effects of a rise or decline in the birth rate in general, but are much more concerned with the problem of what particular social elements are declining and the particular strata increasing its numbers.

Here Bertrand Russell again seems to have gone astray. "What is regrettable at present," states Russell, "is not the decline in the birth rate in itself, but the fact that the decline is greatest in the best elements of the population. There is reason, however, to fear in the future three bad results: first, an absolute decline in the numbers of English, French and Germans; secondly, as a consequence of this decline, their subjugation by less civilized races and the extinction of their tradition; thirdly, a revival of their numbers on a much lower plane of civilization after generations of selection of those who have neither intelligence nor foresight."⁷

The well-known biologist, Professor S. J. Holmes, also comes forth with a biological formula for man. "It may be urged with much reason," he says, "that the birth rate of superior peoples should be kept high in order that they may conquer and supplant inferior types." And again, "since in general officers represent a class superior in intelligence and efficiency their enhanced death rate in war can not fail to have a dysgenic effect."⁸

In making such statements, these observers are unfortunately defending the ideological and practical basis of modern imperialism and the myths of racial superiority. They continually speak of inferior types and of the less intelligent with the same dogmatic certainty that a taxonomist speaks of a well-established biological species. They have, in fact,

⁵ B. Russell, *Power*, p. 12, pp. 157-8. New York: W. W. Norton. 1938.

⁶ E. B. Copeland, in Cattell, *op. cit.*, p. 204.

⁷ B. Russell, *Why Men Fight*, p. 197. New York, 1917.

⁸ S. J. Holmes, *The Trend of the Race*, pp. 123, 209. New York, 1921.

created a static taxonomy of human society and have classified the so-called lower classes as the inferior type. Like good scientists they then assert that the multiplication of an undesirable type must be stopped if humanity is to survive.

But modern anthropology and genetic studies have shown that we can not identify low economic groups with, let us say, a high incidence of feeble-mindedness. It is true that the subnormal mentality is quite often found in the poorest level of society, but it does not follow that low income is a cause of hereditary mental ineptitude. As a matter of fact, low income itself is the result of certain rather basic economic contradictions which have no more relation to the germ plasm of man than the sun spots have to cyclical depressions. It is not hard to see how such well-meant, but superficial, interpretations lend themselves quite logically to a reactionary social dogma.

Another warning, in similar vein, is given by Carr-Saunders, past director of the London School of Economics. He is afraid for the future of man because "the course of evolution has generally been downwards. The majority of species have degenerated or become extinct, or what is perhaps worse, have gradually lost many of their functions. The ancestors of oysters and barnacles had heads. Snakes have lost their limbs and penguins their power of flight. Man may just as easily lose his intelligence . . . if, as appears to be the case at present in Europe and North America, the less intelligent of our species continue to breed more rapidly than the able, we shall probably go the way of the dodo and the kiwi."⁹

We must note that even the interpretation of evolution in the animal world has been seriously distorted by Carr-Saunders. The fact that certain organ-

isms have, in the course of development and mutation, lost many of their former functions and structures is not necessarily a sign that the "course of evolution has generally been downwards." Such a generalization would not be accepted by our leading biologists. The fact that a tapeworm, for example, has lost the complex structure of its ancestors shows us that it has become progressively adapted to a life of efficient parasitism. From the standpoint of an endoparasitic existence the evolution of the tapeworm has been one of remarkable specialization and not degeneration. As far as the snakes are concerned, they seem to get about quite ably without limbs and they have, in their own "degenerate" way produced an apparatus that man has but recently discovered, "and this in the shape of an instrument of immense value to himself—the hypodermic needle."¹⁰

Has evolution proceeded upward or downward, backward or forward? To seriously consider such a question is to take the step of entering the field of metaphysics and teleological reasoning. In dealing with the factual evidences for organic evolution the biologist does not superimpose anthropomorphic conceptions upon natural ecological systems in order to explain them. Carr-Saunders looks at the limbless snake and reasons that this creature is degenerate because it lacks certain structures found in the highest form, man. He has not made a scientific study of the suborder Ophidia in order to observe if this "degeneration" exists in the facts (he need merely consult authoritative sources to find that the theory is false), but is quite content to distort the findings of genetics and ecology by assuming a morality of progress as operative in evolutionary transformation.

This logic is similarly applied to the view of man. Man is also an animal

⁹ A. M. Carr-Saunders, in *Evolution*, pp. 110-125. Ed. by G. R. de Beer, Oxford, 1938.

¹⁰ R. L. Ditmars, *Reptiles of the World*, p. 121. New York, 1940.

obeying the same evolutionary laws as the snakes and barnacles; hence, it is argued, there is a good chance that man may lose his own marks of progress, that is, intelligence (head), hands, speech, etc. Intelligence is considered as solely and directly correlated with hereditary mechanisms and as something quite distinct and isolated from the social context in which it moves. This is not too far from the "blood thinking" of fascist theory.

Here again is that confusion which links economic problems to biological bases; a point of understanding that leads directly toward the camouflaging of our most pressing social problems in a biological arena whose laws have no fundamental relation whatsoever to the forces of the social complex. We shall never arrive at any satisfactory solutions to such problems as poverty and dependency until we are willing to see them in their real social aspect. The introduction of analogical reasoning from biology for the solution of social problems is the introduction of that type of pseudoscience upon which the theoreticians of the corporative state have based their political-biologies of the super race.

Certain men of science expound the theory that all the characteristics of a progressive human culture are inherent in the nature of man. One might say (to carry out this logic), for instance, that the physical predisposition for the ideas expressed in the Bill of Rights was an integral component of the germ plasm of the Founding Fathers. How have these advanced ideas become fixed in the hereditary apparatus? One type of analysis holds that our notions of the rights of man have gone through the process of natural selection during the course of human evolution and have lived because they have a survival value. Thus Professor S. J. Holmes concludes that "from the Darwinian standpoint . . . both man's fighting instinct and

the higher qualities which lead him to give unselfish service to his fellows are alike produced by natural selection for the sake of their survival value in the struggle for existence."¹¹

Similarly, M. F. Guyer, of the University of Wisconsin, transforms Mendelism into a dogmatic theory of history by his assertion that "the intellectual, moral and spiritual characteristics which constitute the source of a nation's social institutions and government are in the main but the outward expression of the strong inherent trend that is a part of the very being of the people of that nation. Change its racial stock and inevitably its institutions must change. Free institutions are but the expression of free men, and the spirit which makes and keeps men free is largely inborn."¹²

These statements imply that human progress can only develop by the special catalytic effect of biological evolution which impresses good cultural qualities upon the genetic structure through the mechanism of natural selection. Man is chained to the biologic wheel; he is able to effectuate social change with about as much certainty as he can direct the evolutionary disposition of the vermiform appendix or the nictitating membrane. For the growth of society "is a vast process, where the forces are massive and act with unhurried deliberation." Man must simply wait for the course of evolution to complete itself; he is, at best, a creature of adjustment. ". . . the elemental forces of the societal realm . . . can not be mastered; they must be studied and known and adjusted to, as a condition of social well-being."¹³

The relation of man to the process of social transformation is thus seen to be

¹¹ S. J. Holmes, *Human Genetics and its Social Import*, p. 277. New York, 1936.

¹² M. F. Guyer, *Being Well Born*, p. 396. Indianapolis, 1927.

¹³ A. G. Keller, in *The Evolution of Man*, pp. 126-151. Ed. G. A. Baitsell. Yale University Press, 1923.

a passive one and at best man may obtain a more rational attitude toward his fate by study and adjustment. Man's fate "can not be mastered." The implication is that any striving for a better world with the belief that society can be organized and planned scientifically is a mirage and an illusion. Such concepts as "democracy, freedom, self-realization, civilization, nay society itself, are but snares for fools, if they beguile us into revolts against the primary laws which were established in the beginnings of life."¹⁴

Why is it that these distinguished scientists make the common point of emphasizing the impotence of man in the face of so-called natural forces? Is it not the very essence of science itself to enable society to act upon and change these forces to man's advantage?

One answer has been directly put by Harvard's Professor East. He maintains that "... it is probably wiser not to try to change abruptly ..." the "... system of slow and orderly advance ..." Utopias are ... too revolutionary. ... Man's "... reasoning power is a recent product, his animalism is ancient and firmly established. The student of heredity may well content himself ... with directing attention to those little problems of every-day life which genetic knowledge may help one to understand, leaving others to pen idealistic constitutions."¹⁵

Thus the persistence of man's so-called animalism is put as the barrier to social change consciously worked for and directed. On this basis it is difficult to understand how man's recently established reasoning power can even cope with the "little problems of every-day life." This is a political philosophy of scientists who believe it is correct to impress a concept of the long and vast

process of evolution upon the solution of basic social problems. In political practice it gives aid and comfort to the *status quo* ideas now being practiced by the Nazi conquerors in their own educational system and upon the peoples of occupied Europe. Overlooked and obscured is the fundamental fact that the slow advance of the little problems finally becomes transformed into a qualitative leap; that change is not evolution taken alone but is, at the same time, a series of social mutations.

Any high-school biology student is aware that the history of organisms has shown a development from unicellular to multicellular forms. This fact is interpreted by some workers as a sort of guarantee that human society will follow the basic trend of development from autocracy (one-celled) to democracy (many-celled). Is it not clear then, "... if evolution is a fact, the change in character of physiological dominance and integration from the autocratic toward the democratic type may perhaps make us a little more hopeful regarding the future of mankind in the course of biological time, even though the character of dominance in some of the social integrations of the present day is far from encouraging."¹⁶

The future of democratic economic and political systems has thus been guaranteed by the history of biological differentiation and specialization. Even in the face of fascism, which "is far from encouraging," we need merely pursue a course of enlightened isolationism since, in the long run, democracy is certain to arrive like a bus. This is an old theory in a new form. It is a bit toned down but, nevertheless, the result of that same philosophical speculative research which induced Ernst Haeckel to call progress "a natural law which no human power ... can ever succeed in suppressing."¹⁷

¹⁴ F. C. S. Schiller, *Eugenics and Politics*, p. 32. New York, 1926.

¹⁵ E. M. East, *Mankind at the Crossroads*, p. 298. New York, 1926.

¹⁶ C. M. Child, *op. cit.*, p. 180.

¹⁷ Quoted by E. Nordenskiöld, *The History of Biology*, p. 511. New York, 1928.

It is rather paradoxical to say now that it may take this war to teach biologists that progress and democracy are not natural laws but man-made laws which can easily be negated if they are not consciously and purposefully fought for and worked for. The change from "autocratic" to the "democratic" type is not a product of biological evolution but depends directly upon the speed with which a majority of humanity will sufficiently realize the necessity for democracy to fight for it. The present war has already done much to crystallize such a cognition of the external world.

To continue the argument of those who believe that human progress is predicated on biological laws, let us now ask the following question: What is the mechanism established by evolution, within the framework of this supposed irresistible trend toward progress, that will carry on the day-to-day function of integrating the good society? Is it man's intellect, his reason? Is it the consciously applied activity of man in his relation to nature whereby he establishes his material production and likewise changes his material environment and, at the same time, transforms his own nature and his own thoughts? We find the answer apparently in the negative. It is not reason, consciously applied and planned activity, or scientific method; it is "instinct."

The integrating factors in all animal societies are instincts rather than intelligence . . . even in man, instinct is more universal and more powerful than reason . . . instinct and not reason is the source and ultimate cause of human society as well as of most human behavior.¹⁸

This was written about a generation ago by a well-known professor at Princeton during the heyday of instinctivist biology. And now, what do we find at the present time?

Herd instinct is a social qualification. The intellect is not. It is individual, in the long run

¹⁸ E. G. Conklin, *The Direction of Human Evolution*, pp. 90-91. Scribners, 1921.

anti-social . . . just as instincts held together the groups of man's predecessors in whatever measure was good, so man's feelings, partly instinctive and all in part instinctive, have always performed this service for him, even in opposition to intellect.¹⁹

Thus science itself deprecates that greatest of natural historical achievements, the human brain and its distinctive power to reason. It is hostile to an organ which gives man, in contradistinction to all other life, the unique possibility of changing the world in the direction of greater and greater human progress. This, above all, is a crowning piece of defeatism which, were it to become a part of the national philosophy, would set back the advance of democratic states by as much as the contempt for manual skills set back the development of scientific and experimental medicine.

Darwinism, in its contemporary and nineteenth century aspects, does not constitute a biological point of departure which may be utilized to explain and solve the problems of human society. As a matter of fact, Darwin's own evaluation of man in *The Descent of Man* was precisely the same as his treatment of animal development in *The Origin of Species*. Man was observed to have been developed from a series of animal forms through natural selection by means of the struggle for existence. *Homo sapiens* was regarded as a true taxonomic species standing on the top-most rung of the ladder of animal development. Man was declared to be an animal.

This was a revolutionary event in itself, since it cracked the stagnating influence of the theological theories of special creation and catastrophism. It did nothing, however, to establish the fact that man's animal relationships were historically of minor significance as compared to the fact that the interaction between man and nature had produced the very materials and mode of a new

¹⁹ E. B. Copeland, *op. cit.*, pp. 204-5.

type of existence, namely, human society. This, as yet hardly recognized, was the great contribution of materialism in philosophy and the scientific method in sociology.

There is, nevertheless, in a very profound sense, an actual application of Darwinism to society. Here we have reference to the method and the reasoning arrived at by Darwin in order to set up a realistic interpretation of life consistent with the facts in nature. This great contribution to the scientific method was an integral part of that great movement in thought which made possible a higher synthesis in the understanding of natural and human history than had ever been dreamed of before.

What Darwin did was to sweep away, once and for all, the unscientific division between theory and practice, between nature and the facts in nature. This establishment of the scientific method in biology, with its implications for the social sciences, exploded the traditional and static *a priori*ism that considered only those forms as legitimate species that fitted neatly into predetermined systematic categories. The problem of understanding the external world became a practical problem and theory was recognized as condensed practice. It was the elevation to first rank of the principle that laws and generalizations can only be found in the facts; that they are not immutable but change according to changes in practice—the primacy of practice.

This was truly an intellectual revolution which shook the very foundations under such antiscientific reasoning as that of the famous comparative anatomist, Baron Cuvier, who held the factual evidence for organic evolution in his laboratory but refused to admit the logical conclusion since it did not square with the accepted doctrines of special creation and catastrophism.

Darwin himself was probably unaware of his great methodological contribution.

In such ideas as the Pangenesis and sexual selection his reasoning was remarkably akin to the speculative natural philosophy of early nineteenth century German biology. As a matter of fact Darwin actually committed the grave error of applying human concepts to the explanation of biological change, exemplified in his use of the Malthusian doctrine and in his anthropomorphic characterization of certain animal traits. However, these shortcomings, which have been the focus of attack by certain narrow-minded historians of biology, do not detract from the circumstance that his theory of evolution exploded the prevalent idealistic and romantic theories and made changes in nature the connecting links in history rather than changes in ideas.

For the first time it was possible for man to turn scientific reasoning upon his own sphere of existence and find the laws of social dynamics in his own practical activity. But Darwin's method gave man the opportunity of even more than this. It pointed out (on purely biological grounds, of course) not only the important fact that the world is in constant flux and change, but that the relationship between organism and environment is a dialectical antagonism and unity; that every species changes both itself and nature in the process of living;²⁰ a relationship which is continually in a state of transformation, and an example to man of how he himself had been changed and can still further change the world. This added profound weight to the philosophical proposition

²⁰ Darwin, in chapter 3 of the *Origin of Species*, states, for example (among a great host of instances), that "if certain insectivorous birds were to decrease in Paraguay, the parasitic insects would probably increase; and this would lessen the number of the navel-frequenting flies—then cattle and horses would become feral, and this would certainly greatly alter the vegetation; this again would largely affect the insects; and this . . . the insectivorous birds, and so onwards in ever-increasing circles of complexity."

that the problem of understanding the external world is, at the same time, the problem of its transformation.

In this sense we find the actual application of the Darwinian or the scientific biological method to the society of humanity. The whole development of modern science with its brilliant achievements in the field of basic productive instruments gives proof of the correctness of the scientific method to which Darwin made fundamental and world-shaking contributions. It is unfortunately true that man has only recently begun to think in terms of applying this method to the solution of economic, political and social problems.

Today, in the midst of war and fascist reaction, many research workers understand that the application of scientific method finds its own negation in the practice of isolating it from all, but a few, segments of the social milieu. Many scientists have at last recognized the vital necessity of repudiating the idea (held by such educators as Hutchins of Chicago) that scientific method and scientific control are the special possession of monks of learning; that the participation of scientists in everyday social and political activity debases knowledge.

They have seen that science has heretofore been quite irresponsible in its lack of attention to the problems of unemployment, economic depression, wars, fascism, etc., and that, in the immediate past, an unnatural division has been drawn between scientific activity and its social aspect.

Today natural scientists must learn to take a scientific view of the changes constantly occurring in a dynamic society, strictly from the standpoint of the human level; for the entire arena of social action is not only part and parcel of their own lives but the fulcrum upon which the future progress of science in a democratic society is delicately balanced. They must develop their sense of responsibility to a correct interpretation of social events and change, and most important, "they must develop techniques to deal with that continuum. Otherwise they will become passive onlookers upon sequences of events that should be, in some measure, under their control."²¹ We do not seek a blind faith in a better world but are confident in the empirical knowledge that men make their own history.

²¹ T. Swann Harding, "Science and Agricultural Policy," p. 1101. *U. S. Yearbook of Agriculture*, 1940.

PROBLEMS OF THE DEHYDRATION INDUSTRY

By DONALD K. TRESSLER

GENERAL ELECTRIC COMPANY

During the present emergency, the preservation of foods by drying and dehydration has become a matter of vital importance. There are three reasons for this:

First, owing to the shortage of shipping, great emphasis must be placed on the elimination of the greatest possible weight from foods which are to be shipped to Great Britain and to our armies and those of our allies. Since fresh vegetables contain nearly ninety per cent. water, while dry vegetables contain only five to eight per cent. water, it is obvious that one pound of dehydrated vegetables has approximately ten times the food value of a pound of fresh, canned or frozen vegetables. Since fruits have a much higher percentage of solids, due to their much higher sugar content, the same ratio of advantage does not hold for them. However, even in the case of fruits, the dried or dehydrated product has about three times the food value of the fresh product of equal weight.

Second, when our armies and those of our allies are on the march, and it is necessary for each man to carry his own ration, it is obvious that the food carried must be in a concentrated form.

Third, there is a shortage of tin which may become acute in the near future. In all probability, it will be necessary for us to preserve our perishable foods by means other than heat sterilization in tin containers. Of course, glass can be used but our glass factories can not supply a sufficient number of glass jars for all of our canned goods. Further, there are not sufficient cold storage warehouses to permit the freezing and storage of all our perishable foods. Therefore, it will be necessary for us to preserve by dehy-

dration a considerable part of the fruits and vegetables now being canned.

Because of the war emergency, dehydration of foods has become one of our major food industries. New and improved methods of dehydrating vegetables, fruits and meats have been perfected. Admittedly, the present products are greatly superior to those previously offered. The big question is: are they good enough to stand competition with fresh, frozen and canned foods? Time alone can tell. However, a consideration of the problems of the industry and the shortcomings of the product may give an indication as to what the answer will be.

DEHYDRATION SYSTEMS

Drying is the oldest and simplest means of food preservation. All that is necessary is to reduce the moisture content of a food under eight per cent. and to pack it in a tight container, and it will "keep" indefinitely (i.e., remain free from spoilage by microorganisms). Dehydration can be done in currents of warm air or in a vacuum. Tunnel driers are most common, although drying cabinets are also being used.

Many different types of drying tunnels are in use. In order to dehydrate a vegetable rapidly to a low moisture content, it should first be subjected to a high temperature. Later, when the moisture content has been reduced to twenty per cent. or lower, the temperature should be reduced to a point below the critical one for the vegetable undergoing dehydration. Near the end of the process, the humidity must also be low; otherwise it is impossible to get a product with a low moisture content.

These conditions are easily obtainable in the tunnel designed by Eidt which is popular in the eastern sections of Canada and the United States, being extensively used for the dehydration of vegetables (Fig. 1). This tunnel is constructed in two sections: (1) primary, and (2) secondary. Hot air is blown in at each end and is drawn out at the middle; thus in the primary section of the tunnel the movement of the hot air is in the same direction as that of the product on the trucks, whereas in the secondary part of the tunnel the flow of air is counter to that of the product.

Drying operations are somewhat more easily controlled in a cabinet dehydrator, but the capacity per unit of floor space is less. In the cabinet dehydrator, the trays of food are placed on a truck which in turn is moved into a chamber in which the air is drawn through a fin type steam radiator by a blower which blows the air over the product at a velocity of 600 to 1,200 linear feet per minute. Only a

portion of the warm air is exhausted; most of it is recirculated through the radiator and then again over the product.

Vegetable "purées" and some milk and eggs are dehydrated on drum-driers. A drum-drier consists essentially of a steam or hot-water-heated revolving drum made of corrosion-resistant metal. The liquid, or purée, is spread in a uniformly thin film over the drum as it slowly revolves. In thirty to sixty seconds, when the drum has made about two-thirds of a revolution, a thin film of the dehydrated product is scraped off. Because of the great speed at which drying takes place, the quality of drum-dried products is excellent. The main disadvantage of the process is that it is not suitable for the dehydration of either whole fruits or vegetables or even small pieces of these products.

Liquid products, such as milk and eggs, may either be drum-dried or spray-dried. Spray drying is carried out by

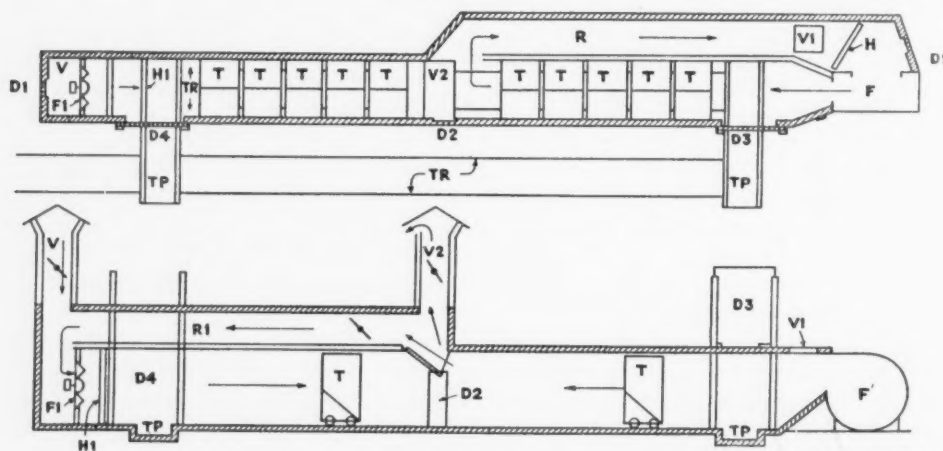


FIG. 1. AN EIDT TUNNEL DEHYDRATOR

T, Trucks; Arrows Indicate Direction of Air Flow; R, Air-Return Duct Between Finishing Chamber And Fan; R1, Air-Return Duct Between Primary Tunnel And Finishing Chamber; F, Conoidal Fan To Circulate 40,000 Cu. Ft. Per Minute In Primary Chamber; F1, Propeller-Type Fan To Circulate 20,000 Cu. Ft. Per Minute In The Finishing Chamber; H And H1, Heaters For Primary And Secondary Ends Of Tunnel Respectively; D, D1, D2, Two-Foot Door To Allow Entrance To Fans And Heaters, And To Make Truck Exchanges In Tunnels; D3 and D4, Counterbalanced Doors To Allow Intake And Outtake Of Trucks; TP, Transfer Pits; V1, Intake Duct For Use When Finishing Chamber Is Not Operating; V, Intake Duct; V2 Outlet Duct; TR, Track; Shading, Insulation.

atomizing a liquid or semi-liquid product in a special chamber into which hot air is blown. The liquid evaporates so rapidly that it remains relatively cool until it reaches the cooler zone of the drier. Most of the powder falls to the floor of the chamber. That which is entrained is caught in bag type dust collectors equipped with automatic unloading devices.

Large quantities of milk, eggs, lemon juice and a few other liquid foods are dehydrated in spray-driers.

PROBLEMS OF VITAMIN CONSERVATION

Dehydration processes are simple, but if one is to retain the full palatability and nutritive value of the food, the problem is far more complex. In general, the methods now employed for the drying and dehydration of fruit conserve the nutritive values of the fruit well, with the exception of its vitamin C content. If the fruit is sulfured during process of preparation, the vitamin C content is retained, but vitamin B₁ is destroyed. What is needed is some agent which will prevent the darkening of the fruit and also preserve both the vitamin B₁ and vitamin C content.

The problem of preserving the full palatability and nutritive values of vegetables during dehydration is even more difficult. During the last war, most of the dehydrated vegetables produced were lacking in flavor, texture and nutritive value. Since then we have learned that it is absolutely necessary to scald the vegetable before dehydration. Scalding not only improves the palatability of the freshly dehydrated product, but also permits the storage of the dehydrated vegetable for considerable periods without marked loss of flavor and color. It also aids materially in conserving the vegetable's vitamin content, particularly vitamin C.

Another noteworthy improvement is the dehydration of vegetables in two

stages. Stage one is accomplished at a relatively high temperature (180 to 200° F). As long as the food is moist, it will remain cool, owing to the rapid evaporation of its moisture in the rapidly moving air of relatively low humidity. When the food becomes nearly dry, evaporation slows down, and the product warms up nearly to the temperature of the air; it must then be moved over into another part of the dehydration equipment in which the second stage of dehydration is carried out. The latter is effected at a point somewhat under the so-called "critical temperature" for the vegetable being dehydrated. In the case of onions, this temperature is about 140° F. The critical temperature of cabbage and saurkraut is approximately 145° F. Some other vegetables—for example, beets—may be finished at a temperature as high as 165° F.

In general, properly scalded dehydrated vegetables prepared under optimum conditions retain all of their nutritive values well, with the exception of vitamin C. Work carried out at the New York State Agricultural Experiment Station¹ determined the losses of vitamins occurring during commercial dehydration of cabbage, rutabagas, beets and potatoes. Relatively small losses of carotene and thiamin and large losses of ascorbic acid were observed. The data are summarized in Table 1.

Researches now in progress promise to reveal how vegetables may be prepared and dehydrated without marked loss of vitamin C. Preliminary studies seem to show that if the vegetables are scalded with superheated steam or steam under pressure, a much higher percentage of the vitamin C is retained than if the product is scalded in boiling water or ordinary live steam.

¹ D. K. Tressler, J. C. Moyer and K. A. Wheeler, 1943. "Losses of vitamins which may occur during the storage of dehydrated vegetables." *American Public Health Journal*, Vol. 33, No. 8, 975-979 (1943).

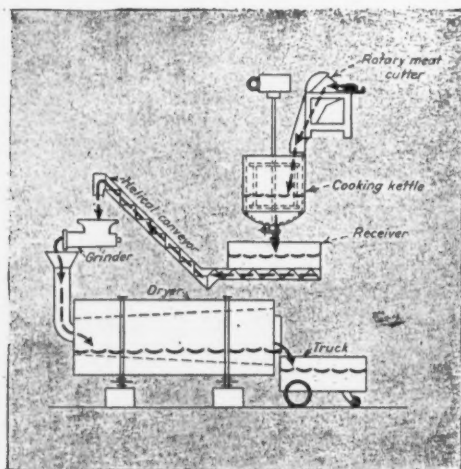
TABLE 1
LOSS OF VITAMINS DURING COMMERCIAL DEHYDRATION OF VEGETABLES IN CABINET DEHYDRATOR

Vegetable	Per cent. loss during dehydration		
	Carotene	Thiamin	Ascorbic acid
Cabbage	(a)	5.4	19
Rutabagas	9.0	16.7	87
Beets	(a)	19.5	29
Potatoes	(a)	24.6	100

(a) Not determined—little carotene was present in the original fresh vegetable.

DEHYDRATION OF MEAT

Meat is now being successfully dehydrated on a very large scale. Fresh beef is first cut up, then cooked under steam pressure. The cooked meat is ground and then fed into a rotating drum of a horizontal dryer (Fig. 2) in which air heated to 300° F is forced at a velocity of approximately eight hundred feet per minute through the tumbling mass of



Courtesy of Food Industries

FIG. 2. FROM THIS DIAGRAM OF THE PRODUCTION LINE FOR DEHYDRATING BEEF THE RELATION OF EACH OPERATION AND PROCESSING UNIT TO THE OTHERS CAN EASILY BE SEEN.

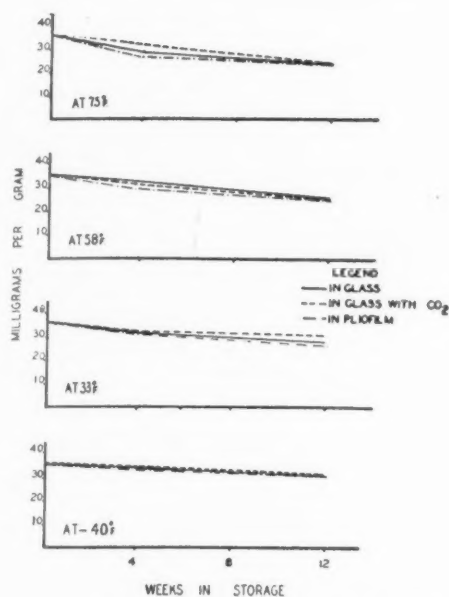
finely divided meat. Dehydration is accomplished in about two hours. The product resembles cooked, not fresh, meat. Consequently, it is suitable for use in hash, meat-loaf and the like. Dehydration carried out at a very low temperature is the only method that has been found that will yield a product substantially the equivalent of raw beef. According to this process, the meat is first frozen and then, while frozen, dehydrated in *vacuo*. The product is excellent but the cost of production is high.

In the case of most dehydrated meat and meat products, the fat content offers difficulties because it tends to turn rancid during long continued storage. Anti-oxidants are needed which will inhibit this action. Guaiac gum is being used by some packers to retard the development of rancidity.

The dehydration of whole milk offers more obstacles than the dehydration of skimmed milk, since here again it is necessary to stabilize fat in such a way that it does not turn rancid during storage. Packaging of the product under high vacuum or under an inert atmosphere, such as carbon dioxide or nitrogen, retards—but does not stop—the development of rancidity.

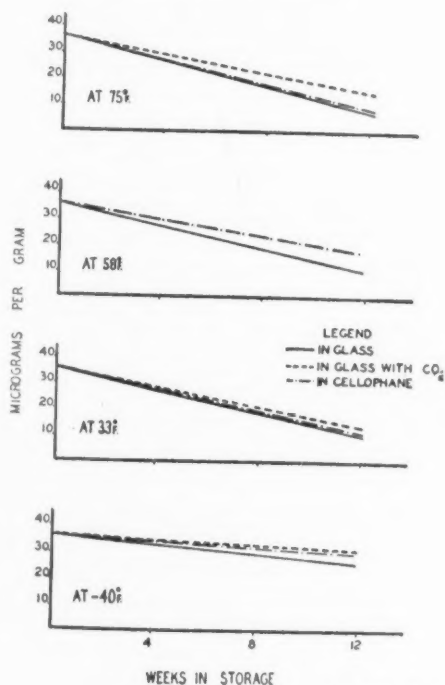
STORAGE PROBLEMS

Most freshly dehydrated vegetables are of high quality, comparable in color and flavor to the original vegetable, but gradually decrease in flavor, color and vitamin content during storage. In some instances, off-flavors develop and the product turns dark in color. Onions, cabbage, carrots and sweet potatoes deteriorate in storage somewhat more rapidly than the other vegetables commonly dehydrated. At ordinary room temperatures, for example 70° F, the rate of deterioration is relatively slow. Thus, even the products listed above retain their quality for six to nine months. If, however, the temperature is raised to



From Tressler, Moyer and Wheeler

FIG. 3. ASCORBIC ACID CONTENT OF CABBAGE IN STORAGE.



From Tressler, Moyer and Wheeler

FIG. 4. CAROTENE RUTABAGAS HELD AT VARIOUS TEMPERATURES.

90 to 100° F, the loss of quality is very rapid, particularly in the case of the four vegetables named. If these products are packed under carbon dioxide or nitrogen, their palatability, color and vitamin content are retained somewhat longer.

Storage losses of carotene and ascorbic acid are much greater than those of other vitamins. Thiamin losses are negligible. Refrigeration aids in retarding losses of both carotene and ascorbic acid, but the temperatures must be very low if the losses are to be reduced to a minimum (Figs. 3, 4; Table 2).

The lower the moisture content, the slower the rate of loss of quality and vitamins at any given temperature.² However, it is difficult to remove the last few per cent. of moisture from these vegetables.

From the above, it will be seen that, if dehydrated vegetables are to be stored for a considerable period of time, it is important first to reduce the moisture content to the lowest level practicable and then to store the products under refrigeration. If these precautions are taken, any of the dehydrated vegetables can be maintained in excellent condition for a year or even somewhat longer.

Dehydration results in a very great reduction in the weight of the vegetables. However, loosely packed dehydrated vegetables occupy a relatively large volume per unit of weight. During the past year or two, it has been found that it is a relatively simple matter to compress most of the vegetables commonly dehydrated into small blocks, usually called "briquettes." In the case of dehydrated cabbage, for example, it is possible to compress the contents of a five-gallon can to a volume of approximately three quarts, thus effecting a seven to one compression. If the dehydrated vegetables are to be shipped overseas, space saving is almost as important as weight saving.

² E. M. Chace, "The present status of vegetable dehydration in the U. S.," 1942 Proceedings Inst. Food Technologists.

TABLE 2

ASCORBIC ACID CONTENT OF STORED DEHYDRATED RUTABAGAS*

Period, months	How stored	Storage temperatures			
		-40° F	33° F	58° F	75° F
0	.....	0.42	0.42	0.42	0.42
1	In air in glass container	0.32	0.47	0.28	0.36
	In cellophane bag	0.47	0.47	0.36	0.38
	In CO ₂ in glass container	0.38	0.60	.....	0.39
2	In air in glass container	0.27	0.45	0.43	0.26
	In cellophane bag	0.34	0.55	0.26	0.24
	In CO ₂ in glass container	0.34	0.36	.....	0.35
3	In air in glass container	0.38	0.35	0.37	0.31
	In cellophane bag	0.44	0.40	0.38	0.43
	In CO ₂ in glass container	0.43	0.46	.....	0.34
4	In air in glass container	0.41	0.21	0.18	0.16
	In cellophane bag	0.38	0.26	0.19	0.19
	In CO ₂ in glass container	0.42	0.34	.....	0.17

* From Tressler, Moyer and Wheeler, loc. cit.

It is of importance to use just sufficient pressure to compress the vegetable so that it will remain in a solid block when the pressure is removed, and not enough to cause it to be pressed into such a solid block that refreshing can be accomplished only with great difficulty. It is evident that briquetting will become important only when the resultant blocks can be refreshed in a relatively short period of time.

IMPORTANCE OF PROPERLY COOKING DEHYDRATED VEGETABLES

Although many persons have been engaged in researches to determine how vegetables may be dehydrated and the product stored without marked loss of nutritive values, only a few have given consideration to those methods of cooking which will prevent serious loss of vitamins during preparation for the table. It is evident that losses which occur during final preparation are just as real as those taking place during dehydration and storage. Researches carried out by Fenton and co-workers³ have

³ F. Fenton, B. Barnes, J. C. Moyer, K. Wheeler and D. K. Tressler, "Losses of vita-

shown that increasing the volume of cooking water from the minimum amount required caused a very marked decrease in the amount of thiamin and ascorbic acid retained by the cooked dehydrated vegetable. Perhaps this should have been expected since these vitamins are so easily soluble in water. Steamed vegetables were found to retain about the same amount of the water-soluble vitamins as those boiled in a small amount of water without previous refreshing.

Regardless of the method of cooking, no actual destruction of thiamin was noted, although when dehydrated vegetables were boiled in large amounts of water, much was dissolved and lost in the cooking water. More work should be done to show how preparation losses may be kept low.

During the past few years, dehydrated soups and dehydrated soup mixtures have become popular. Many of the products prepared by mixing dehydrated vegetables, dehydrated milk, soybean flour and monosodium glutamate are ex-

mins which may occur during the cooking of dehydrated vegetables." *American Public Health Journal*, Vol. 33, No. 7, 799-806 (1943).

cellent, being fully the equivalent of those which may be produced in the home kitchen. Furthermore, they are simple to prepare, requiring only the addition of boiling water.

Home dehydration is becoming an important practice. Owing to the scarcity of commercially canned, frozen and dehydrated vegetables and to the shortage of equipment for home canning and freezing of vegetables, many housewives are turning to home dehydration as a means of preserving their surplus vegetables and fruits.

The state experiment stations have published directions for the dehydration of all kinds of vegetables and fruits, and are also furnishing plans and directions for the construction of dehydrators which may be used in the kitchen.

Recently, the War Production Board has authorized the construction of 100,000 home dehydrators well adapted for kitchen use. An excellent type of home dehydrator consists of an electric heating element, an electric fan and a thermostat housed in a cabinet containing a number of trays on which are placed the vegetables or fruits which are to be dehydrated. The fan blows air heated by the heating element over the trays. Usually

the air is continuously recirculated; only a small amount of moist air is continually exhausted and an equivalent quantity of fresh air is drawn in. The principal differences between commercial cabinet dehydrators and the better ones now offered for use in the home kitchen are size and source of heat, most commercial dehydrators using steam.

Housewives willing to take the trouble to prepare vegetables and fruits properly will be able to produce a product comparable in quality to that of the present commercial preparation. The general use of these dehydrators will mean a great increase in the quantity of perishable foods preserved in the home.

The future of the dehydration industry will be bright in post-war days if the storage problem can be solved. If serious losses of quality occur during the period that dehydrated vegetables are on the grocer's shelves, the quality of the vegetable offered the housewife will be variable. If the products are not properly stored, the housewife will literally, and figuratively, have a bad taste in her mouth and will not continue using dehydrated vegetables when she can purchase unlimited quantities of canned and frozen vegetables of high quality.

RACIAL STATUS AND PERSONALITY DEVELOPMENT

By ALLISON DAVIS

DEPARTMENT OF EDUCATION, THE UNIVERSITY OF CHICAGO

RACIAL dogma, with its network of folkways, maintains that the bodily marks which differentiate between groups of men externally likewise divide them into groups of the pure-blooded and the impure-blooded, of the cultured and the uncultured, of the ambitious and the lazy, or the politically capable and the politically incapable.

These powerful ramparts of unreason, of folk-lore, of group dogmas and hostilities have been referred to by Dr. Redfield¹ as constituting what he called "a modern mythology." In brief, this mythology of race states first, that a man's typical behavior, whether biological, social, political, educational or psychological, can be predicted upon the basis of his physical appearance and attributed to his racial inheritance; it holds secondly that the physical stocks of men are innately unequal in many of their important functions, and that changes in environment will not stimulate changes in these relative inequalities.

As a biological scientist, Dr. Krogman² had a swift and complete victory in his part of this tournament of lancing against racial myths; for, as he said, there is no proof either that the bodies of one race of men are less well adapted in themselves to survival than those of another, or that those physical differences which distinguish in a general way between physical stocks of men have any bearing upon the intellectual or cultural behavior of these races of men.

This social behavior by which one distinguishes between groups of men is not

racial, but cultural, in origin, Dr. Redfield next pointed out; and it is cultural, he would say, in the sense that it is the product of the social experience of the individual in that particular way of life (that culture) which has constituted his social environment. Not race but society determines man's culture and psychological behavior; the best evidence for this conclusion is, as Dr. Redfield said, that all cultural behavior is learned behavior. None of it is inherited in the blood stream, nor in the genetic structure; none of it is transmitted by the mere fact of membership in a certain race, nor even by the mere fact of birth into a certain family. All of this social or cultural behavior must be learned by each new human organism through the laborious processes of imitation, identification and the other learning processes. Dr. Redfield thus disposed of the myth that race is at the basis of cultural differences by pointing out that men learn their culture (including, he said, their racial attitudes which they lack as young children). Since culture is not transmitted biologically, physical race has nothing to do with it. Not his race, but the kind of a society, the type of institutions, the degree of economic and social opportunity which the individual finds available to him will determine the richness and complexity of the culture he learns.

Perhaps the belief in racial or ethnic types of personality is the most common and spontaneously expressed form of racial dogma. For example, southerners are taught from early life that Negroes, as a group, are childish, irresponsible, lazy and primitive. Italians, so our

¹ *The Scientific Monthly*, Sept., 1943.

² *The Scientific Monthly*, Aug., 1943.

American folklore and popular literature tell us, are carefree, artistic, sensuous and hot-tempered. Filipinos, as seen by western eyes, appear innately vain and childish in their love for display, as well as irresponsible and frivolous. Even the Yankee has been considered, at least by certain other nationalities, to have a "racial" personality; he is supposed to run to the money-grasping, uncouth, aggressive type, and from the European viewpoint to be culturally naive and unsophisticated. Since there have always been numbers in each of these groups who exhibited the behavior which the myth said was inherent in their "racial" nature, it followed that anyone who believed the myth about Italian or Negro or Yankee personality could find some choice cases to confirm his emotional belief. The fact that the majority did not exhibit this stigmatized behavior did not discredit the myth for those who were taught to believe it. Furthermore, there is a general conviction in our society that personality, or character, is inborn, inherited, or predestined. Thus it is generally believed that nothing can be done to change personality; one is supposed to be born with it, just as one is born with race. For this reason, the myth of racial types of personality is even more deeply rooted in our folklore than is the myth of racial types of culture. Many in the general public may come to agree that a man's culture is a function of his social environment; that culture is learned. But very few will so agree with regard to personality. In the popular thought, personality itself has something elemental and instinctive about it. What could be more natural, then, than to expect a Filipino, an Italian, a Negro, an Oriental to have an inborn, "racially" characteristic personality? They are supposed to have been born that way, and nothing, it is assumed, is capable of changing them.

Yet the great students of human social development, and of the human psyche,

have now made it clear that personality is also a learned pattern of behavior. The differences between babies at birth, no matter what their race, are very slight, and are limited chiefly to differences in physical responses. As soon, however, as the baby's mother and his family begin to care for him and to interact with him socially, they begin to offer a learning environment for him which differs from that of every other baby in some respects. Through this association with his mother and his family, through the processes of his early training with its relative severity, its skill in using rewards and punishments, and through his changing emotional relationships with his parents, and brothers and sisters, the child is actually learning that characteristic disposition toward people and situations which we term personality. To protect himself, to win favor, to outdo a brother, to escape from a hostile parent, or a dangerous adult, a child learns to be fearful, or aggressive, or stoical, or vengeful. At the same time, he learns to act as children in his cultural group are required to act; he learns to be a Samoan child, or an Italian child, or a low-status white child in the South. He learns this cultural personality because it is the only kind which is acceptable in his society. A Park Avenue family insists that its children learn upper-class culture, and a poor slum family insists that its children learn the kind of cultural behavior which is considered proper and which will gain them acceptance in their slum community. Now, at the same time that the child is learning how to be a slum boy or a Park Avenue boy, he is also learning his own private adjustment to the world. Both these aspects of development are a part of personality, and each is learned. Neither of them is biologically determined or influenced by race.

Personality is a very complex aspect of human behavior, but let us see if we may state more clearly this dual nature

of human personality, which each of us actually recognizes in his daily experience with people.

You meet a man on a train, and spend the better part of the day in that surprisingly personal type of conversation which is safe with a person who will never see you or your friends thereafter. You recognize two things about him by the time the day is over; he is a man from a rural tenant community, and he has, for some reason, a need for constant boasting. These two facts represent the two chief areas in personality: that of the culture which forms a man, and that of his private, individual life of fear, or courage, or hate, or guilt.

I shall call the latter the private, or individual, personality, and the former the cultural personality. The cultural personality may be defined as that system of human behavior, thought, perception, emotion and values which is taught by the culture. It includes one's behavior as a male or a female, a child or an adult, a slum dweller or an aristocrat, an Italian or a German in a particular community. The cultural personality is extremely complex for most individuals in our society; for example, the same woman often has to learn the social behavior, sentiments, and values of a daughter, a sister, a wife, a mother, and a grandmother! The cultural personality may be so marked as easily to distinguish an individual as a member of a cultural group, at least for anyone who knows the culture of that group. Thus one could tell a southern poor White, or a Samoan, or a Londoner, or an Australian.

On the other hand, one could not tell a man's culture by his greed, or love of art, or boastfulness, or laziness, or meanness of spirit, for these are traits of personality exhibited by some members of all cultures. They reflect the private or individual personality. The private, individual personality is perceived in that

behavior of an individual which distinguishes him from other individuals, even in the same cultural group. In this personal sense, one Samoan is not like all other Samoans; in his individual personality he may be like one's own best friend or best enemy in America!

With this distinction between the two basic aspects of personality in mind, it is possible to consider more objectively the major question before us: What effects does racial status exert upon personality? Italians, Mexicans, southern Whites, southern Negroes, Spanish, and Indian peoples are here considered as social groups, or as what Dr. Redfield termed "socially supposed races" (in the popular thinking). Each of these social groups has a culture, or a number of cultures. Perhaps it is more important for the formation of personality that each of these groups has a status, or a number of types of status in a larger community (or region, or nation). For example, Spanish families in Mexico have the highest status there, as do old white planter families in the South, or old Yankee shipping families in New England. Subordinated to these Yankee aristocrats (in New England communities) in ethnic or, if you will, racial status, are the French Canadian, Polish, Italian and other foreign-born or nationality groups; subordinated to the Spanish families of Mexico are various intermediate groups, with the Indian masses at the bottom; subordinated to the southern white aristocrats are also various groups with the poor Whites and Negroes having the lowest status.

Clearly, membership in an ethnic or racial group which has superior status in a given community is a psychological gain for an individual. It frees him by the very fact of birth from a whole system of limitations, punishments and stigmas to which the members of a subordinate race are subject. The "old Spaniard" in Mexico, the "old American" in

New England, or the White in the South is assured of prestige, social dominance and freedom from systematic subordination on grounds of race, even though he may be a very poverty-stricken, illiterate person. High racial status, therefore, affords to those who possess it a customary, daily psychological security and social prestige which they do not have to earn. To phrase this gain negatively, high racial status protects an individual against the inevitable restrictions, punishments and frustrating taboos to which people of low-racial social status have to submit. High racial status likewise affords an individual the right and the opportunity to be paternalistic, to grant favors and protection, to receive deference and supplication.

What of the psychological responses available to the members of a socially subordinate race? First it must be remembered that the degree, or type, of subordination of racial groups varies. The subordinate status of the foreign-born immigrant in Chicago in relation to the older American group is much less marked than that of the Chinese in California to Whites; the subordinate status of Negroes in the South, and in South Africa under the British and Boers, is actually a condition of caste as rigid as that described by students of Hindu caste.

Severe subordination of a race means limiting the number of economic, social, educational and political roles it can learn; psychologically it means the narrowing of the number of types of responses which the individual can make. In a vast number of economic and social relationships, prestige and attainment are taboo to the member of a subordinate status. He must learn either to be deferential and compliant, or to be aggressive only to the degree and in the situations considered permissible to one of his racial status.

It is not necessarily true, of course, that the most rigid subordination neces-

sarily leads to the greatest frustration of a racial or social group. A group may be so thoroughly subordinated and so cut off from full human participation in the area where it exists that it becomes habituated to those substitute goals and forms of gratification which it is allowed. On the other hand, the member of a race which, although allowed to gain high economic or educational or political status is nevertheless denied social status, may experience far more frustration and personality disorganization than a member of the first group. In this country, however, where every one has learned the dogmas of democracy (of the equality of citizens before the law, of opportunity, of the brotherhood of man), it is true that all subordinated racial groups certainly feel deeply the penalties which are directed against them as a result of their racial or ethnic marks.

I wish to call attention to several factors, other than the degree of racial subordination, which help determine the effect of this subordination upon personality. Before proceeding further with this consideration of racial status, however, I must bring into the picture the other principal influence upon racial experience, namely, culture.

In our modern world, where economic imperialism has brought all races into cultural contact, the individual of a subordinate race is often a man who has learned the ways of two different cultures. In all such cases, the two cultures have different status or rank, from the point of view of either race. In most cases, as was true with the American Indian, the culture of the subordinate race gradually lost status with its own group. Thus in the case of the detribalized or socially disorganized people of Africa, or Burma, or the Pacific, the European culture gained higher prestige in the natives' eyes than their own. The situation is paralleled by the experience of the poor European immigrant in

this country. He gradually learned the culture of America, and came to prefer it to his foreign culture, which he still exhibited. His children not only preferred the American culture, but were very likely to be ashamed of their parents' foreign culture.

These men of two cultures (and sometimes also of two races) have been called "marginal" men by Dr. Park. The important point about the marginal man is that his two cultures do not have equal status, in either his own eyes or those of his neighbors. One is a superior culture, as he sees it, and the other an inferior. Fifteen years ago Dr. Park wrote, "It is in the mind of the marginal man that the moral turmoil, which new culture contacts occasion, manifests itself in the most obvious forms."³ The nature of this frustration and humiliation in the child of the immigrant is illustrated by the following excerpt from a famous autobiography:

I was an alien in my mother's home. I loathed it. . . . Oh, it was not the poverty I minded! . . . But the women who came in their slovenly dresses, content in their stupidity . . . , the men who spoke intolerantly and without understanding of religion and economics, the pale girls who simpered and toiled with the one aim of a dreary married life, the young men who were untidy and dull, or overbearing and conceited when they had education—that was what I saw. . . .⁴

Among the Spanish-Indian urban people of southern Mexico, Dr. Redfield has found a marginal group, intermediate between those of Spanish culture and those of Maya Indian culture—a group which illustrates the great complexity of these situations in which races of different cultures meet.

This [marginal] group may be subdivided into three: the households of Maya-speaking mestizos who have specialized occupations: those, some simple agriculturalists and some specialized workers, where the language is Maya but where the man wears the city costume: and those, where likewise the occupation is various, where the women wear folk costumes (the men having in most cases taken to wearing some of the garments of the city), but where the language of the home is Spanish.⁵

The psychological impact of subordinate racial status upon the member of such a group also depends upon his social status within his own race. The lower-class Oriental farm laborer in California does not experience the same sense of exclusion and isolation as does the high-status Chinese whose family is old in American culture, but is still subject to racial stigmas. The Italian of "Little Italy" is not subjected to the pull of two worlds—and two sets of psychological and status evaluations of these worlds—as is the second or third-generation Italian who has moved to the residential suburbs. As the more acculturated members of subordinate groups attempt to change their status by changing their culture, they become increasingly aware of their ethnic status and hostile to their old culture. At the same time, they are also increasingly subject to punishment from members of the dominant group, which resists the efforts of the marginal men to enter their group.

Where the social group of the racially subordinate individual is highly organized and integrated as in the Little Italies or Chinatowns, or in many southern Negro communities, its members will usually have relatively less psychological conflict over their racial status. Their world is a little society in itself, with strong limitations upon cultural contact. Such situations tend to prevent sharp awareness of their subordinate status by those who live in the segregated community. They are to be contrasted with the marginal type of situation in which a European immigrant

³ Park, Robert E. "Human Migration and the Marginal Man," *The American Journal of Sociology*, 33: 893, 1928.

⁴ Stern, E. G. *My Mother and I*, quoted in Stonequist, Everett V. *The Marginal Man*, Ph.D. Thesis. University of Chicago, p. 242. 1930.

⁵ Redfield, Robert. *The Folk Cultures of Yucatan*. University of Chicago Press, p. 65. 1941.

(in this country), an Oriental or a Negro is living in a neighborhood with American Whites, and is participating in economic or other situations in which he is seeking similar types of status as the American.

An individual's racial status may be expected to have marked effect upon his personality, then, if his race is subordinated in community relationships, if his group is ashamed of its culture and seeking the culture of the dominant group, and if it has no integrated society of its own. In addition, the age of an individual is a crucial factor in determining the scars of racial status upon his personality. The American Youth Commission's recent studies of personality development among Negro children in southern cities revealed that their racial status had a somewhat minor influence upon their personalities. During both the first and second decades of life, these children were more deeply concerned with, and emotionally influenced by, their family, their play-group, their school and church, than by their consciousness of their subordination to Whites. This fact I attribute to their relative lack of direct contact with the white world at that age. As they completed their education, and sought jobs from white businesses, however, they met the full impact of the economic blockade which is maintained against their group by southern Whites. The parents of these adolescents, however, were also interviewed extensively; they showed unmistakable evidence of deep frustration, disillusionment and cynicism concerning their opportunities as Negroes in those cities. For both white and colored persons, it appears certain that race attitudes and their effects upon personality become far more strongly developed as they go through adolescence to adulthood and parenthood; as they grow older, that is, they learn that their status and opportunities for full human participation in this

civilization are vitally affected in a great many points by racial prestige or racial stigmas.

The Italian immigrant child, the Chinese child, the Negro child in this country does not meet most of the racial taboos; but his father meets them daily. Thus the escape and withdrawing reactions, or the negativistic, or the aggressive responses of such adult personalities may be deeply intensified by their adult experiences of the full significance of the economic, educational and political barriers which are organized against them upon the purely arbitrary basis of their racial or ethnic group membership. In the second, or acculturated, generation, the old are the bitter. At the very least, they are the disillusioned.

The fact that racial subordination is a basic psychological deprivation, and the fact that individuals must learn the kind of behavior required by their racial status are illustrated by the reactions of Negroes in the South. There, the population is divided into two castes, Whites and Negroes. One can never change his caste marks, nor his caste status. He is born in his caste, and he must die in it. He can neither earn, nor learn, nor fight, nor marry his way out of his caste. That is why it is, in reality, a caste. Not only are the castes separated, but they are ranked in a hierarchy; the White caste is assured economic, political, educational and social dominance by law, custom and force.

It is difficult for Whites in the deep South to understand the feelings of Negroes in their lower-caste positions. In the first place, as soon as he begins to live in the South, a White is taught the social dogma of his caste with regard to Negroes. On every hand, he hears that Negroes are inherently childish and primitive. He is taught that they lie and steal impulsively—"like children"—that they are unable to control their sexual urges, and that they

share none of the complex social and economic ambitions of Whites. Since Negroes are primitive and childlike, the story runs, they accept their restricted opportunities as matters of course (although children themselves do not do so), and consequently they feel no pain or deprivation in performing the heaviest, dirtiest work, or in undergoing the severest discriminations. In many essential points, the southern dogma concerning Negroes is the same as that held by the slave-owning classes almost a century ago.

The second difficulty which Whites meet in understanding the experiences of Negroes as lower-caste people is the rigidity which the caste system has attained in the South. Negroes and Whites, for example, seldom have face-to-face relationships, except in necessary economic transactions. In those immediate relations which they do have with Whites, Negroes must always act deferentially. In life, this means that the colored individual seldom expresses to Whites, by word or by action, the frustration or resentment which he may feel toward them. On the contrary, he must dramatize his subservience by using deferential forms of address, and by accepting without open aggression those punishments with which the Whites subordinate him. To a White who observes Negro behavior from his own caste position, therefore, Negroes may appear perfectly accommodated and happy.

Yet we know that Negroes in the deep South are continually expressing to each other the deepest sense of frustration over their position in society. They verbalize these tabooed feelings only to their colored friends or to colored interviewers, and to northern white men—that is, to members of those groups which will not punish them for such expressions. In order to penetrate the rigid surface of the caste system in our own South, and to get at the human experi-

ences and motivations which are imbedded in the tough, protective layers of custom, one must talk with people in their own terms, therefore, and live in their part of society.

When social psychologists have studied Negro personality in this intimate way, they have concluded that southern color caste must be viewed as a systematic interference in the efforts of a special group of individuals to follow certain biological and social drives. This interference takes the form of a complex of limitations in addition to the accepted controls of our society upon all individuals.

A White or a Negro in the South learns the behavior demanded of him in his color-caste position chiefly by experiencing (or anticipating) pain or deprivation if he attempts to reach a goal by any other route than that prescribed by the society. To the Negro child, as our cases show, caste presents a group of arbitrary behavioral demands which he is compelled to learn. He is forced into these learning dilemmas both by his Negro parents and by the white children and adults with whom he has contacts. When the colored child is learning to behave as a lower-caste person, he is finding a method of acting within the frustrating taboos of caste so that he may reach those limited and substitute goals which the society does allow him.

Both the white and the colored child acquire their caste training in two types of relationships: in their family and from non-family members of their own caste, and in contacts with members of the other caste. At the age of five or six, the child learns that he must sit only with his fellow caste members on the bus or in the theater, and that he must attend schools which have only children and teachers of his own caste. Within his family, he receives instruction in the behavior required toward members of the other caste. As he becomes adoles-

cent, both the definiteness and the parental reinforcements of this instruction increase greatly, for it is then that the occupational and other taboos become matters of urgency.

In general, the Negro child learns from Whites that he can not be a member of their economic, social or educational groups. He also learns that he must not be aggressive toward them, but must dramatize his subordinate position by various explicit forms of deference. From his own family, he usually learns that Whites are extremely powerful and dangerous and that he must, therefore, not display aggression toward them. If even the powerful adult can not resist Whites, what can the child hope to gain by attack? He is taught, however, that within the bounds of his caste position he may adopt substitute modes of aggression toward Whites. For example, certain well-disguised forms of getting even, such as sabotage in his work for Whites (slowness, lack of punctuality, clumsiness), and the use of flattery, humor, secretiveness, ignorance and other behavior for outwitting Whites, are learned at an early age.

The actual caste behavior of the parents themselves appears to be more important in determining the child's type of accommodation to Whites than does verbal instruction on this point. As in other forms of learning by identifying with a person who has already learned, the child discovers what behavior will be punished and what rewarded by observing his parents and listening to their accounts of experiences with Whites.

The child whose parents are of unlike class origins usually receives one type of caste instruction from his mother and a different type from his father. For example, if the father is of lower-class origin, he will almost certainly tell his son to submit to all White demands unless he is threatened with violence, in which case he should fight. If the mother

has been trained in a middle-class family, she will probably teach the son to avoid Whites and not to fight them under any circumstances. A child who lives in such a family, or in a family where one parent has been reared in the South and the other in the North, is placed in a continual and almost insoluble dilemma, which may be expected to increase his anxiety and maladaptive tendencies as compared with the child whose parents have the same class and sectional origin.

The second type of conflict in the caste training of the Negro adolescent is especially prevalent in cities. It is the dilemma of the ambitious child who is beginning to associate with, and to assume the behavior of, a class which is above that of his parents. The first step in such a rise in their class status for the mass of lower-class colored children in Natchez or New Orleans is to finish a high school course. In this process of educational advancement, the colored adolescent faces a conflict between the caste instruction and example given him by his teachers, who are usually middle class and by his parents, who are lower class. The middle-class teacher not only gives the colored child instruction in skills associated with the White caste, but he has gained professional status. Such differences in caste training apply both to etiquette and to the choice of an occupation.

In this situation, the Negro child usually identifies with his teachers: that is, he rejects the training and example of his lower-class parents who must be deferential to their white employers and who must accept domestic or manual labor. When he completes high school, such an ambitious child faces the basic caste restriction against skilled and clerical work for Negroes. In order to achieve a middle-class position, he must therefore either go on to a higher school and become a teacher or he must obtain a position as a clerk in some Negro bus-

iness. If he is unsuccessful and has to accept a menial or domestic job under a white supervisor, he experiences a basic frustration upon both color-caste and class grounds.

This analysis of the personality formation of Negro children in the South bears out the theory that personality is not inherited; it is learned. The fact that personality, disposition, and character form a learned pattern of behavior means that there can be no racial "inheritance" of personality. People are not born with their personalities; they acquire them by experiences in a social environment. Finally, it is evident that there are no racial types of personality because within each race there are several social strata, each of which has a different culture, and each of which teaches different kinds of behavior and psychological goals to its members.

If one wishes to know what one may expect of a man, one needs to know in what kind of a culture, not in what race, he has been reared. More than anything else about a man or a woman, however, one needs to know what his loves, his fears, his hates are, and what he considers valuable in life, and valuable beyond life. Certainly there is not one of

us who has not met a man of another group or race who was congenial, or brave, or honest, or self-sacrificing or honorable. All of us also have met members of our own and of other groups, or races, who were cowards, or imposters, or murderers at heart.

If one wishes to know whether one may depend upon a man, or trust him behind one's back, or with one's children, or stand shoulder to shoulder with him against a common enemy, one needs to know his individual nature, not his race. The troubles of this chaotic world of international anarchy in which we live are not made by this race nor by that race; they are made by men who hate, and lust for blood and revenge; by men who envy, and crave for personal dominance and aggrandizement. The greatest possible benefit to mankind which one can conceive would be the practice of dividing men into groups according to whether they wished to kill, to dominate and to plunder, or whether they wished to cooperate, to share, to advance human development one step beyond the jungle stage in which we now live—to be men of good will. Such a division of mankind would bring together men of every color and race.

THE AGE OF FLOWERING PLANTS

By Professor EDWARD W. BERRY

DEPARTMENT OF GEOLOGY, THE JOHNS HOPKINS UNIVERSITY

If you were to ask the president of almost any of the numerous garden clubs in the United States, "What is a flowering plant?" she would look both surprised and puzzled. She might even feel sorry for you for asking such a silly question. If you were tactfully to pursue the subject into the question of the ancestry of the flowering plants, it might be admitted that of course plants had ancestors. So what? Plant genealogy has not the personal appeal of human genealogy, nor is it so dramatic as the ancestry of the horse, elephant, rhinoceros or camel. There is nothing in the ancestry of any plant comparable to that of the giant wolves or saber-tooth tigers of the southern California asphalt deposits.

Most educated people have some concept of the noble races of animals that have moved across the world stage during the millions of years of the Age of Mammals. But students of fossil plants have had many handicaps; their subject-matter is much less complete and confessedly less exciting. Sporadically a "Save the Redwoods League" disseminates information about sequoia genealogy, and the history of the Oriental maidenhair tree, or ginkgo, has been repeatedly written, but for the rest little has been written and still less has become a part of general consciousness. Moreover, paleobotany has had no patrons, like the great oil company that has sponsored the discovery and restoration of the dinosaurs, or like the late W. C. Whitney, an admirer of race horses, who gave princely sums for the study of the geological history of horses. Nor have our great museums fostered studies or exhibits of fossil plants. They

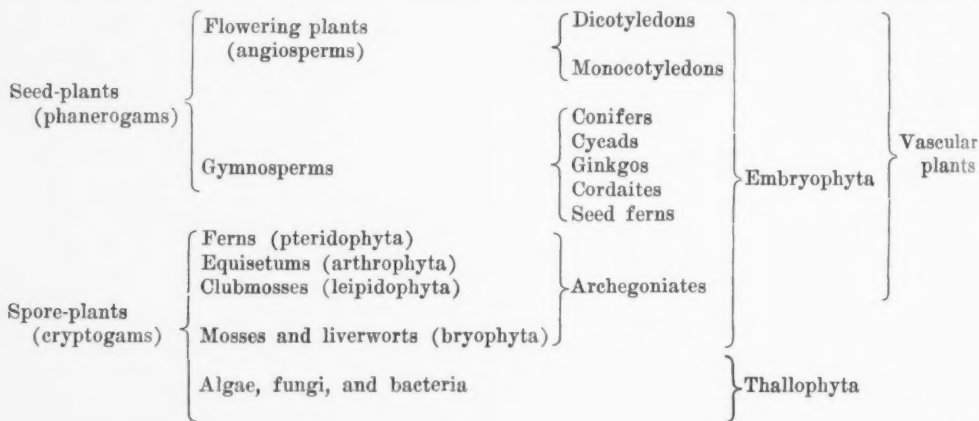
have halls of mammals or reptiles, but the fossil plants are in the attic or cellar or storage warehouse. And there is yet to be organized an expedition to Patagonia to collect fossil plants, or one to the West Indies or Central America, which might throw much light on the subject of former land connections in that important region.

But let us get back to the lowest common denominator of general knowledge about plants. We can divide the Vegetable Kingdom into two great groups, which we call, for the sake of simplicity, seed plants and spore plants, roughly comparable to, and as a matter of fact more exact than, the division of the Animal Kingdom into vertebrate and invertebrate animals. The seed plants may again be divided into flowering plants and gymnosperms (conifers), or those that organize what we call flowers and produce seeds in closed fruits and those that have naked seeds in cones, like the pines and sequoias. The spore plants are less complex, and all their living members—on land at least—are relatively small, although some of their ancestors in the ancient coal period were far from simple and were of gigantic size.

The spore plants are relatively unknown to most people; the only group of them with which the average plant lover has any familiarity is the fern, and this familiarity is not too precise, since neither dealers nor gardeners hesitate to include under ferns the asparagus-fern, which is not a fern but a flowering plant. In the East we call a very handsome shrub the sweet-fern, although it is really a myrica, another flowering plant. Nearly everybody knows the names of some of the other groups of spore plants,

such as mosses, seaweeds and fungi, but they would be hard put to it to explain why a clubmoss is not a moss or what the fundamental difference is between a mushroom or toadstool and an alga.

The accompanying greatly simplified outline will enable one to visualize the whole Plant Kingdom, and it will also make clear some of the terms for concepts that have been used by those who have discussed some of the larger and more theoretical problems of the evolution of plants on the land.



But to confine our attention to the flowering plants, we have to ask ourselves not only what a flower is but also why flowering plants are important. The definition or at least the recognition of a flower would be no problem to an amateur gardener or to a honey-bee, but morphological botanists have expended more thought upon this botanical problem than on almost any other and have used considerable ink in trying to frame the correct definition. It all started in Goethe's time with a certain ideal of a flower and a comparison of all others with the ideal and perfect concept. Schemes of classification and keys for identification have been almost wholly based on flower structure.

Nearly everybody knows the parts of an ordinary flower; for example, that of a cherry or a buttercup. In the center

there is what is called a pistil, a style that leads down to an ovary in which the ovules are fertilized and develop into seeds. Surrounding the pistil are few or many stamens, *i.e.*, slender stalks with sac-like expansions at their tips in which the pollen is formed. Pistils and stamens are the really essential parts for the reproduction of the plant. Outside these is usually one or more series of often brightly colored organs known as petals and sepals. These organs are unessential for reproduction, except as they

have been adapted for attracting various kinds of insects that visit them and carry pollen from flower to flower and thus effect cross-pollination or cross-fertilization.

Now we come to the difficulty of framing a definition. Is the flower to include merely the essential stamens and ovary? If so, then many plants that are not related to the flowering plants have flowers. Shall the criterion be the colored parts? If so, many flowering plants do not have flowers. Are the so-called double monstrosities, such as roses, altheas and tulips we cultivate, flowers, since most of them lack the essential parts and do not form seeds? What shall we say of poinsettias, snow-on-the-mountain, hydrangeas and the flowering dogwood in which the bright parts are not sepals or petals but

proliferated bud scales, colored bracts or leaves? And then again we have a host of so-called catkin-bearing plants like the oaks, poplars and willows, which have the essential organs but lack colored floral envelopes. Our only recourse is to fall back on common sense and admit that we can not frame an all inclusive definition.

From the beginnings of modern botany the flowering plants have been divided into two great groups. These are the monocotyledons, once mistakenly thought to be the most ancient, and including lilies, palms, orchids, and grasses; and the dicotyledons, including oaks and maples and the majority of garden plants. The names embody the facts that there is one seed leaf (cotyledon) in the first and that there are two in the second; they differ in a number of other and mostly unimportant particulars in stem, leaf and arrangement of flower parts. There has been much discussion as to whether both groups are descended from a common ancestral stock, which is the oldest, and whether all within the group are blood relatives. It would take us too far into details to develop this genealogy, important as it is.

The flowering plants are easily the dominant plants of the modern world, the most adaptable to all sorts of environments. They exhibit almost infinite variety and are what we should call highly successful. Compared to them the other great group of seed plants—the conifers—are underprivileged and appear adapted to a hard life. Hundreds of thousands of species have been described. Although much more ancient than the angiosperms, the inability of the gymnosperms to compete for a place in the sun indicates neither that they suffered a misspent youth nor that living conditions were harsher in the past. They can not compete with the flowering plants simply because their organization is less efficient. Flowering plants have

a better circulatory or vascular system, directly to be correlated with a greater display of assimilating surface (green foliage). Most conifers have more or less xerophytic foliage; that is, their leaves are for the most part reduced to needles and their cuticles are more impervious to gases. Flowering plants have their tissues better ventilated; most of them grow faster; they have better devices for the protection, fertilization and nourishment of their ovules, and above all they have highly developed methods for maturing and disseminating their seeds, in which they pack miniature seedlings with foodstuff to give them a start in life.

Volumes have been written on the various means perfected by plants for scattering their seeds. These range from such simple devices as wings (or parachutes) to more mechanical means, such as that found in the witch hazel, which by a process of drying and contraction of the seed walls ejects the hard seeds with as much efficiency as a small boy can shoot a slippery orange seed by squeezing it between his fingers. Or they may develop a torsion in some part of the fruit, which shoots away the seeds, as, for example, in the wild geranium known as cranesbill, or in the little balsam known as touch-me-not.

Hundreds of other plants have their fruits in the form of hold-fast-burs, stickseeds, or beggar-lice, which accumulate on your clothes during an autumn walk or which stick to the feathers or fur of birds and mammals and are thus disseminated.

Small seeds of water plants often dry in the mud pellets on the feet of water birds and are carried long distances to new wet places. Or seeds may develop so resistant a seed coat as to pass unharmed through the alimentary canal. Especially is this true of hosts of small fleshy fruits like cherries, grapes, mulberries and brambles, whose seeds are

unharmd by their digestive journey but may be dropped miles away, with an appropriate amount of fertilizer. Many stream-border plants are equipped with special devices for being carried intact for long distances, like the European water chestnut (*Trapa* or caltrop) introduced in recent years into North America. Most specialized for floating are forms like the snuffbox bean, which retains its vitality and is unharmd for weeks in ocean currents. There are quite a number of West Indian forms that journey regularly to Europe via the Gulf Stream.

Nut-bearing trees like the walnuts and hickories trust to luck that their fruit will be carried away and buried by squirrels and then forgotten.

The importance of the fruits and seeds of the flowering plants to the warm-blooded animals and to man rests on this habit of storing foodstuffs in seeds and fruits, and to a less extent in roots or tubers. Some of them, notably the cereals, in this way store as much as one-third of the dry weight of the whole plant.

Mammals are known in the geological record for millions of years since the period that geologists call the Triassic. Through all this time until late Cretaceous they were few and small. Then followed the time when modern-looking flowering plants appear in the geological record, and the mammals underwent that marvelous evolution that makes the Age of Mammals the quite proper appellation for the latest of the geological eras.

From the quite human point of view man was the culmination of the evolution of the mammals. Even as good a churchman as Linnaeus classed man and the apes in the order called Primates. Anthropologists are agreed, however, that primitive man could not have advanced beyond the hunting and fishing state of culture had there been no flow-

ering plants—the foundation of agriculture. Even that less advanced state known as nomadism was dependent on flocks and herds, which in turn depended on pasture, which again is furnished by the flowering plants—gregarious plants like the grasses yielding food for the gregarious animals such as sheep, cattle, yaks and camels.

We get a picture of primitive agriculture in the deposits of the lake dwellings of central Europe—the Robenhausian culture—about 10,000 years ago. Agriculture permitted permanent dwellings, increase in population, domestication of some of the wild animals and development of pottery (primarily for storage), and these inevitably resulted in social customs that gradually crystallized in codes. The final result—what we call civilization—would obviously not have been possible had it not been for the evolution of the flowering plants and the great increase in food that their special adaptations for seed production permitted.

The problem of the origin of the flowering plants has always interested scientists. Nearly a century ago Charles Darwin wrote to his eminent countryman, Sir Joseph D. Hooker, complaining about the total lack of information on this subject, and we are little better off at the present time. There are two methods of approaching the problem. One is by way of the comparative morphology of existing plants, but this has not proved particularly fruitful, first because the modern plant is a product of ages of modification scarcely realizable, especially against the background of geological time as we now evaluate it, and further because we have many compelling traditions, derived from the Pentateuchal concepts of a world only a few thousand years old. In such a brief span as the latter it would be natural to suppose that all plants were rather closely related and that the more complex were

genetically related to their simpler contemporaries. It has become increasingly clear that in those survivors of ancient lines constituting the existing floras the actual relationships are collateral and that our genealogical tree is not a tree at all with a central stock and many branches, but really a bunch of parallel or diverging stocks.

The second method of approach to the problem of the ancestors of the flowering plants is by investigating their fossil history; that is, by studying the actual documents of evolution preserved in the rocks and in the order of their succession. This would be fine except for the fact that this record is very fragmentary—not only are the actual fossil plants in fragments but also the record itself is distressingly incomplete. It can be truly said of the flowering plants, as well as of all the other major groups of plants, that the really remarkable discoveries of paleobotanists of the past thirty years instead of closing any of the gaps or furnishing us with so-called "missing links" have raised new problems, and we are quite as far from our goal as ever. It has also become clear that the ancestral lines go back much farther into the past without converging, and we are finally lost in a conflicting plexus of structures and a corresponding plexus of ideas.

Before discussing the geological history of the flowering plants it is necessary to say something about time. Bishop Ussher calculated that the earth was created in 4004 B.C., and this has been the orthodox view since the seventeenth century. Neither geologists nor students of evolution could reconcile their discoveries with so youthful a world, and in the past hundred years or so there has been a great variety of attempts to get more precise values. There is no need to enumerate these methods—all have proved to contain too many assumptions and too incomplete data. The currently fashionable method

is based on the atomic state of certain radioactive minerals found in the rocks. It seems better to us and probably is better. At any rate it will give the perspective we seek.

I am taking for my purpose the figures in Bulletin 769 of the U. S. Geological Survey published in 1925. These are not the latest or best, as the subject is actively being studied by chemists, physicists and geologists, but this is not serious, since we are only concerned with relativity and round numbers. We may then present the following time table, which covers the younger part of the geological column during which the flowering plants are supposed to have evolved:

Cenozoic, or Modern Era (55 to 65 million years)	Pleistocene ...	1 to 1½ million years
	Pliocene	6 to 7½ million
	Miocene	12 to 14 million
	Oligocene	16 million
	Eocene	20 to 36 million
Mesozoic, or Medieval Era (135 to 175 mil- lion years)	Cretaceous ...	65 to 85 million
	Jurassic	35 to 45 million
	Triassic	35 to 45 million

The situation with respect to the geological record of the flowering plants is about as follows: Very modern-looking leaves are abundant in the record back to a little beyond mid-Cretaceous times, which carries us back 85 to 105 million years. Many of these leaves, like those of sassafras and tulip poplar, have sufficiently individualistic characters to be easily recognizable. Others can not be so positively determined. The point is that the earliest of these leaves show no indications of being different from or more primitive than what we would find in a modern bayou or pond or forest litter. The only difference is that there is a greater similarity between the fossils found in central Europe, Patagonia or North America than we would find today. In other words, the geographical

distribution was very different and more general, *i.e.*, extensive.

Much the same conclusion is to be drawn from petrified wood, several different stems having been discovered in slightly earlier deposits—deposits that geologists refer to as the Aptian stage, called by the English the Lower Greensand. These woods show the same mod-



After Harris

FRUIT OF CAYTONIA

A DIAGRAMMATIC SECTION SHOWING THE SEEDS IN THE FLESH AND CONNECTED WITH THE EXTERIOR BY OPEN MICROPYLAR CANALS.

ern structural organization and can be referred without difficulty to modern families. A petrified flower discovered in the Upper Cretaceous of Japan is unmistakably referred to the lily family.

Obviously these earlier fossils of angiosperms are in no sense primitive or ancestral, and we are no nearer a solution than

was Darwin or Hooker. There are two escapes from our dilemma: We can assume either that the real founders of the dynasty were never preserved as fossils, perhaps because they dwelt far removed from places suitable for their preservation, or that if they were buried and preserved they have not yet been discovered. What seems more probable is that these ancestors were so protean that they have not been recognized as ancestors. That this may eventually be the answer is suggested by some interesting discoveries in the Jurassic of Yorkshire, Sardinia and East Greenland. These discoveries comprise a constant association of foliage, long known as impressions called *Sagenopteris* and once thought to be related to the water ferns, with seeds that have been christened *Caytonia* and *Grithoropia* and with stamen-like bodies (*Antholithus*).

These fruits are fleshy and in two rows on a shoot. Several seeds are imbedded in the flesh and at first sight it seems to be a fruit of a flowering plant. The difficulty is that the tiny seeds have open ends like the seeds of gymnosperms, and Harris has found pollen in these open ends and believes these were connected with the "stigma" by canals. In all known flowering plants pollen falls on the stigma where it germinates, and the developing pollen tube carries the sperms to the completely enclosed ovules. The difficulties of correctly interpreting these not-too-clear petrified tissues caution against too great an enthusiasm, but if the interpretations are confirmed by additional discoveries they will throw our ideas of classification into confusion and give us quite new ideas about the adaptive function of pollen tubes and shed a long-awaited light on our problem.

If the Harris interpretation is the true one, and it seems to be convincing, then *Caytonia* opens a tremendous vista of angiosperm evolution, the open seeds being considered as retreating within fleshy fruits but still connected with the

exterior by open canals, down which the pollen grains found their way to the ovules. It throws new light on the evolution of pollen tubes. The situation observed in the existing cycads and in ginkgo acquires a new meaning as illustrating a stage in the formation and adaptation of pollen tubes. In this stage the pollen freely enters the micropyle, where it germinates as a sort of "hold fast" while the pollen is growing and developing the ciliated sperms, which are then discharged in the vicinity of the archegonia. This stage can now be regarded as an intermediate one.

The later stages would be regarded as steps leading to the complete closure of the micropyle and the development of angiospermy in the modern manner. This would seem highly suggestive, although it would still leave the controversy open as to which group or groups of gymnosperms constituted the true ancestor of the angiosperms.

In so far as the later geological history of the flowering plants is concerned it can be briefly summarized. We find them assuming a leading role in land vegetation during the Upper Cretaceous. There appears to have been a great modernization at the dawn of the Tertiary, perhaps more apparent than real. The early Tertiary appears to have been a time of optimum climates. Equatorial types spread long distances into both the North and South Temperate Zones, and Temperate types penetrated far into the polar regions. The subject is too complicated to be adequately discussed but appears to be partially explained by continental submergence and widespread oceanic climates, perhaps accompanied by the melting of polar ice caps.

There is nothing in the later Tertiary history except shifts in the distribution and the gradual shifting of warmer types toward the equator. Then, with the maximum elevation of the continents to at least their present relative proportions,

there was ushered in the Pleistocene glacial period. This did lots of things to the plants. The floras of all the northern continents had previously been essentially similar. Europe had its magnolias, hickories, tulip trees and sassafras, along with ginkgo and many others. After the ice was gone Europe emerged with a depauperate flora (owing to geographic and topographic reasons), and two great Tertiary forest reserves remained—one in southeastern North America and the other in eastern Asia. The bald cypress and the tulip tree and a host of others no longer flourished along the Columbia River. The sequoia and many others became extinct in the Great Basin as well as elsewhere in the world but fortunately survived in the redwood region and the fog belt of the Sierra Nevada.

Not only was the Pleistocene glaciation responsible for a vast amount of rearrangement in the distribution of plants, but it also mixed soils, altered drainage patterns, blotted out vast areas and when melted opened these areas to recolonization. All this had evolutionary effects, and there is considerable evidence for the belief that many of our large herbaceous families, such as the cresses, pinks, mints and composites, had their chief expansion in interglacial and post-glacial times. I do not mean to imply that these families were absent earlier, but they were much more insignificant members of plant society then than they are now.

This brings us to the end of our story and to the world as we see it (clothed with verdure, if not in its right mind)—to the lush tropical jungles of the equatorial zone, the vernal and autumnal brilliance of our own latitudes, and the tundras of the north with their dwarf willows and birches. We end our journey where the plant morphologists and taxonomists start, but I believe ours is the truer picture, even though it has not led us to a botanical Nirvana.

BOOKS ON SCIENCE

DOCTORS OF THE MIND*

WHAT stands out in this book is the comprehensive and thorough manner in which the subject is discussed. Bibliographical research studies, visits to laboratories and to psychiatric institutions, and interviews with authorities in their respective fields provided the author with an enviable amount of scientific material. This is conveyed to the reader (probably intended mainly for the lay reader) intelligibly and entertainingly.

The story begins with a survey of the origin and development of the human brain. *Homo sapiens* is reminded, in a language that should not hurt his pride, that his nervous system has gradually evolved from such insignificant things as the sea anemone, the jelly fish, the worm, the frog—up to that more respectable being—the ape.

Köhler's experiments with chimpanzees on the Canary Islands are recounted vividly and colorfully, yet without doing injustice to the observed facts. The reader's curiosity about the human-like behavior of the chimpanzee is soon satisfied by the author's incursion into the science of paleontology to show, "a steady progression from small brains with low intelligence to bigger brains with better intelligence—from ape-like to man-like brains." Then the reader is initiated into the intricate investigations of Broca who discovered that certain areas in the brain control the understanding of either uttered or written words. Broca's studies have paved the way for the search for brain centers connected with other functions.

The story of mesmerism, hypnosis, the origin of the concept of the subconscious, and of psychotherapeutic methods (Mesmer, Braid, Bernheim, Liébeault, Janet, Chareot, Dubois, Dejerine) offers fasci-

* *Doctors of the Mind; the Story of Psychiatry.* Marie Beynon Ray. Illustrated. 335 pp. \$3.75. 1942. Little, Brown and Company.

nating reading. Rejected by the medical profession and nonmedical scientific workers, Mesmer remained nevertheless true to the general precepts of the official science in insisting on his theory of "animal magnetism" to explain what were obviously mental influences. Without recognizing it, Mesmer was the first to demonstrate the therapeutic value of suggestion and good rapport between patient and physician.

Kraepelin's teaching that mental diseases are essentially physiological or organic is discussed in the light of available knowledge on the anatomy and physiology of the brain (Broca, Hughlings Jackson) and the chemistry of the glands of internal secretion (Abel).

The story of the advent of psychoanalysis (Breuer, Freud), of the differences between Freud, Jung and Adler, with Adler's individual psychology, epitomizes the fundamental issues in the concepts of the respective schools. This chapter brings forward the controversies between the so-called physiological and psychological psychiatrists and their common aspiration to win "victory in the war on mental disorders."

"Fighting Fire with Fire," "I Saw a Resurrection," "The Insulin Hour," "And the Devils Departed," "Shocked into Their Senses"—these are the spectacular or scare-titles of chapters recounting the advent of the malaria treatment (Wagner-Jauregg), insulin therapy (Sakel), pharmacologic and electric convulsive therapy (Meduna; Cerletti and Bini). It occurs to the reviewer that the story told in these chapters is informative and interesting enough to hold the attention of the reader without resorting to the expediency of arousing emotions with catchwords. Equally factual is the tale of various other up-to-date therapeutic procedures.

The discussion of the concepts of organically minded, psychologically

mind and middle-of-the-road psychiatrist relies largely, if not exclusively, on interviews. In the main, the author succeeds in conveying to the reader the different viewpoints regarding the nature of mental disorders and their treatment. There are, however, serious flaws for which, perhaps, those who were interviewed are more responsible than the interviewer.

This book was read by the reviewer with mixed feelings: first and foremost, an appreciation of the writer's very serious delving into a great variety of scientific disciplines and of the lucid presentation of each of the many topics. At the same time, the highly dramatic tone of the presentation, which appears to be kept up intentionally throughout the entire book, gives the impression of melodrama. The reviewer is satisfied, however, that the melodramatic element does not obscure the drama of psychiatry.

S. KATZENELBOGEN

THE LIFE WORK OF G. E. MOORE*

THIS work is a collection of nineteen descriptive and critical essays dealing with the philosophy of one of the main leaders in the revival of philosophic realism since the beginning of this century. Moore's views on ethics and on method are also discussed by some of the contributors. A reply by Moore to his critics closes the book.

An opening autobiographical sketch affords interesting and, sometimes, vivid glimpses of the intense philosophic activity of at least one little group in Cambridge University during the nineties. In 1903, when the writer was thirty years old, his first important paper—"The Refutation of Idealism"—was published in *Mind*. From that time to his visit to the United States in October, 1940, Moore has written one paper after

another dealing with different aspects of the problem of perception. His editorship of *Mind* since 1921 has undoubtedly enhanced his prestige and the "carry" of his views.

The essays in the present work have titles which indicate the points in Moore's theory where the critics felt impelled to comment or criticism. Thus, O. K. Bouwsma discusses Moore's theory of sense-data; C. J. Ducasse examines his early *Mind* article of 1903; Paul Marhenke considers Moore's analysis of sense perception; C. A. Mace takes up the question of how we know that material things exist; and Arthur E. Murphy writes on Moore's defense of common sense. Another essay, called "Moore's Paradox," by Morris Lazerowitz, with quiet, sustained and controlled humor, glances at the ways in which a professed idealist contradicts his assertions in his acts and utterances. His explanation, however, of why and how an intelligent and sincere man can profess idealism, does not commend itself to Mr. Moore and will probably commend itself to very few readers.

It should be remarked that *The Philosophy of G. E. Moore* does not contain anything like a symposium on idealism versus realism; possibly for this reason only one contributor notes (and that merely in passing) that what Moore has had so large a hand in doing, has been a revival of the Scottish Philosophy, the philosophy, that is, of Thomas Reid, Sir William Hamilton and James McCosh of Princeton. From another standpoint it has been said of Moore that he "put a strong curb upon the exuberant speculations of Hegelianism." But however it be put, his influence has been immense in vindicating sobriety in dealing with the problem of the mind's grasp on the world.

But what definite solutions has Moore attained? Dr. Rudolf Metz, in "A Hundred Years of British Philosophy," says: "Though we may call Moore the greatest,

* *The Philosophy of G. E. Moore*. Paul Arthur Schilpp, editor. Illustrated. Vol. IV in "The Library of Living Philosophers," xvi + 717 pp. 1942. \$4.00. Northwestern University.

acutest and most skilful questioner of modern philosophy, we must add that he is an extremely weak and unsatisfying answerer." Of the truth of the eulogistic portion of this comment there can be hardly a doubt; indeed, Moore's ability to pounce on a contradiction, especially when latent; to pull out nonsense from what some unfortunate writer had deemed to be a massive display of intellect, appears unsurpassed in severe philosophic literature. One recalls the Duke of Wellington's comment on Napoleon: that never was there an opponent before whom it was more dangerous to make a false move.

But what of the rest of Dr. Metz' verdict? Here is Moore's own comment in his "Reply": "I think Dr. Metz was quite right in saying that I am an 'unsatisfactory answerer.' . . . I think it is a just charge against me that I have been able to solve so few of the problems I wished to solve. I think probably the reason is sheer lack of ability and partly that I have not gone about the business of trying to solve them in the right way."

If Moore has not the ability required, the likelihood that anyone else has is not very high; but perhaps his second suggestion hits the nail on the head. The problem of perception first attained what might be called scientific formulation in the disputes between the Stoics and the Academics of Athens.¹ In this debate several assumptions, obviously regarded as self-evident, were made by both parties; and these assumptions have not only come down the ages but they seem to be taken up, as a matter of course, by all who have dealt with the question. To deny them would seem more paradoxical than idealism; yet perhaps it is just these tacit postulates that have deflected the stream of thought concerned with the problem.

FREDERIC DREW BOND

¹ A little treatise dealing with this matter has come down to us from antiquity.

FOOD POISONING*

"It was something I ate," is the self-diagnostic explanation offered by all too many people for a pain anywhere between the base of their neck and their hips. "Indigestion" is such a convenient catch-all and so innocuous in implying just a temporary little upset. Food poisoning is classed as one of the commonest and least dangerous of maladies by the man on the street. He is wrong on both counts. Just how frequent true food poisoning of one sort or another is, we do not know. Most individual attacks and many small family outbreaks go wholly unreported and are never seen by physicians. On the other hand, when a number of people are simultaneously affected, particularly following some public banquet, the newspaper scare-heads make much ado; politically minded reformers belay the local health departments with charges of gross laxity and sometimes the furor of excitement is carried over into legal suits for damages. To ignore food poisoning as insignificant is stupid; to wax passionate and belligerent over every outbreak is equally illogical. Somewhere between these extremes lies the truth.

Just now a new, authoritative, accurate and clearly presented book on food poisoning is particularly timely. War has brought about profoundly significant changes in our food supply; qualitative as well as quantitative changes. War manpower shortages have affected food processing, packing and preserving plants. A recent newspaper item mentions the delay in canning tomatoes because of inadequate help at the canneries. Hotels, restaurants and institutions cry aloud for kitchen help. What help is available is usually untrained, incompetent and wholly unconscious of the simplest rudiments of sanitation and hygiene. Victory gardens and amateur home canning in glass jars invite spoilage of food. Commercially canned

* *Food Poisoning*. G. M. Daek. 138 pp. \$2.00. 1943. University of Chicago Press.

foods always have been and always will be infinitely safer and usually more nutritious than "homemade" fruit or vegetables. Inadequate equipment, guesswork, lack of skill and lack of practical knowledge on the part of the patriotic amateur preserving for the first time are in sharp contrast to the adequate equipment, scientific control of temperature and pressure in sterilization, and sense of serious responsibility found in commercial canning practices. This coming winter, when the amateurs begin to consume what the insects and summer appetites have left of the Victory garden crops, a considerable increase in food poisoning is to be expected.

Professor Dack includes under the broad term of food poisoning those acute, explosive illnesses generally characterized by gastro-intestinal upsets due to *ingestion* of an offending agent. Among such agents are chemicals, poisonous plants and animals, bacteria and their toxic products, protozoa and helminths. The major emphasis is upon those disorders due to bacteria and their toxins.

Though the volume is small and is not illustrated, it is tightly packed with sound information. Differentiation of the various types of intoxication is clear and concise. Particularly well presented is the valuable material on botulism, the most dangerous and insidious of all forms of food poisoning. The text is liberally documented with references. The volume is not a textbook, nor is it a highly technical discussion suitable only for digestion by bacteriologists or physicians. It should prove to be of considerable value to all those concerned with food poisoning. And such are many. As collateral reading in courses in medicine and home economics and for those involved in the preservation, preparation and handling of food, it will reveal much necessary information. City

and state public health officers, the quartermasters corps of our armed forces and industrial food workers can all profit by study of this volume. Specific cases and experimental evidence are cited to illustrate each type of disorder. Of special value are the discussions of methods effective in establishing correct diagnoses in outbreaks of food poisoning. The book is heartily recommended. All those who read it will learn much.

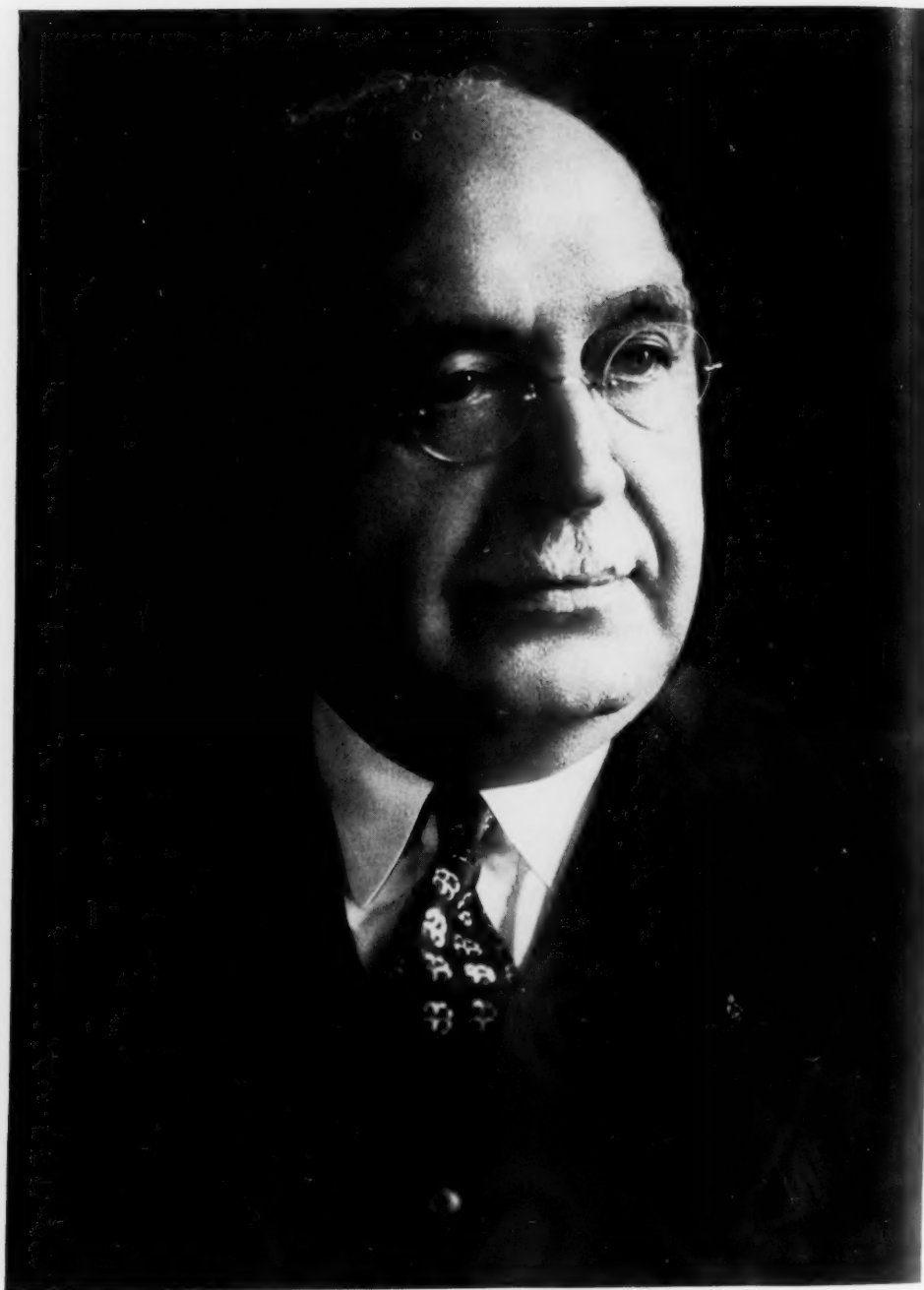
EDWARD J. STIEGLITZ

HOME CHEMISTRY*

For adults who learned no chemistry in high school and now need to know something about it, this is a good rudimentary textbook. It is simple, attractive, well illustrated and—best of all—it gives detailed instructions for scores of simple, revealing chemical experiments that can be done with household or drugstore materials. It is didactic with regard to all theoretical matters, such as atoms and molecules and omits entirely such technicalities as formulas and equations. But it does convey a modicum of the basic concepts and of scientific reasoning from experiment. Most of the book is given to rapid-fire but skilful and sound explanations of common materials of the home and farm. Its scope is no more than that of the first half-dozen chapters of an elementary textbook: air, water, salt, carbon, metals, carbohydrates and cellulose. There is also a descriptive chapter on plastics but the author wisely does not venture into chemicals as complicated as sulfuric acid nor into nutrition, vitamins, dyes and such topics for which the reader is not prepared. His book would make a good companion-piece for a boy's "chemistry set."

GERALD WENDT

* *Getting Acquainted with Chemistry*. Alfred Morgan. Illustrated. 271 pp. \$2.50. October, 1942. D. Appleton-Century Company.



FRANK SCHLESINGER
1871-1943

THE PROGRESS OF SCIENCE

FRANK SCHLESINGER, 1871-1943

DR. FRANK SCHLESINGER'S distinguished career came to a close on July 10, 1943, when he died at the age of seventy-two in his home at Lyme, Connecticut. His death came after only two years of retirement from active academic life.

His principal field of activity was that of photographic astrometry, in which he left a record of impressive accomplishments. He was attracted to this branch of astronomy when he was studying for his doctor's degree at Columbia University (1894-1898). Under the directorship of John K. Rees, the Observatory of Columbia University had undertaken the measurement of numerous photographic plates of Rutherford's collection. The results of these measurements established the importance of the photographic method of astrometry. It became Schlesinger's ambition to apply it to the determination of stellar distances with a long-focus telescope. In 1903 the Carnegie Institution of Washington made it possible for him to spend two years at the Yerkes Observatory. During these years he developed the modern method of determining trigonometric parallaxes. As director of the Allegheny Observatory of the University of Pittsburgh (1905-1920) and as director of the Yale University Observatory (1920-1941) he continued the work begun at the Yerkes Observatory. A most interesting circumstance is that he began his directorship of both observatories with plans for the construction of a new type of telescope particularly suitable for parallax work. For the Allegheny Observatory he designed the thirty-inch Thaw refractor; for the Yale Observatory the twenty-six-inch telescope that was erected at the Observatory's Southern Station in Johannesburg, South Africa. Both are of the photographic type. The decision in favor of telescopes adjusted to photographic light was made

because their efficiency is so much greater than that of visual telescopes used for photographic work.

The importance of the trigonometric parallax is two-fold. It furnishes accurate distances of the nearer stars and, therefore, the distribution of stars in the region of galactic system in the sun's neighborhood. In addition it furnishes a calibration of less direct methods that are used for stars at such great distances that the trigonometric method fails. This calibration requires the carrying out of a systematic program of parallax determinations of the brighter stars without selection on the basis of their distances. It is typical of Schlesinger's service to Astronomy that he concentrated upon this latter field. The *General Catalogue of Stellar Parallaxes*, editions of which appeared in 1925 and 1935, compiled under Schlesinger's direction, shows the enormous progress made since his pioneer work at the Yerkes Observatory.

A second large undertaking in astrometry was the use of the wide-angle camera for the determination of star positions by photography. Here again, high accuracy and efficiency were achieved. The original work was done at the Allegheny Observatory with a camera designed by Hastings and with plates covering five by five degrees. With cameras designed by Dr. F. E. Ross the area of the sky photographed on a single plate was increased to eleven by eleven degrees. This was the size of the plates adopted after considerable experimentation with even larger plates. The success of the work in this field led to an ambitious program that covered one half of the entire sky, and that, when completed, will give positions and proper motions of some 140,000 stars. During the last five years of his directorship of Yale Observatory this program became the main effort of the observatory. He

saw to it before his retirement that all of the measurements were completed, and that the computations were far advanced. At the time of his death about sixty per cent. of the results had appeared in printed catalogues. He had the satisfaction of knowing that every effort was being made to carry the entire program to an early completion under the guidance of Dr. Ida Barney who had been his chief lieutenant in this program from the start.

The results of the two large astrometric programs constitute the main legacy of Schlesinger's activity as astronomer. Both were conceived as large routine programs that were undertaken after patient experimentation in which numerous difficulties had to receive minute attention. The accounts of the experimental work and the precepts for the final procedure have become classics of astrometric research. It has been frequently stated that his colleagues working on related problems turned to Schlesinger's papers whenever they encountered a real obstacle to learn what he would have done in similar circumstances.

It is, no doubt, a very fortunate circumstance for a research man, if he can design and build the instruments that he needs for the specific projects that he wishes to undertake. Less fortunate scientists must adapt their research programs to suit the equipment on hand. During the early years of his directorship at the Allegheny Observatory Schlesinger showed that he could do excellent work in the latter circumstance. The new telescope was put into operation seven years after he became director. During these seven years he used the Keeler Memorial telescope for spectrographic work. The emphasis was upon orbits of spectroscopic binary systems, and the results constitute a most impressive contribution to this branch of astronomy. In the course of this work Schlesinger discovered the rotation effect in the spectra of eclipsing binaries.

Many scientific men who concentrate upon a smaller or larger field of research specialize to such an extent that they have few interests in common with fellow workers in even closely related subjects. This was certainly not the case with Schlesinger. All of astronomy had his interest and his love. As a young man, when he was observer in charge of the International Latitude Station at Ukiah, California, 1899-1903, he formed the habit of faithfully reading all the current astronomical literature, and he enjoyed doing this throughout his career. This gave him an unusually wide knowledge that enabled him to give sound advice to many of his colleagues, here and abroad. On this account, he was also one of the most sought men at the many scientific meetings that he attended.

He was a member of the American Astronomical Society since 1905, and was one of its leaders. At the early age of forty-eight he was elected president, succeeding Newcomb and Pickering. His role in the International Astronomical Union was equally conspicuous and distinguished. He was vice-president for seven years (1925-1932) and president for the three-year term, 1932-1935.

High distinctions of various kinds, in recognition of his eminence as a scientist, came to him in abundance. Among these were his election to membership in the American Philosophical Society (1912), the National Academy of Sciences (1916), and the American Academy of Arts and Sciences (1921). He was a foreign associate in the (British) Royal Astronomical Society (1914), corresponding member of the French Academy of Sciences (1932), correspondent of the Bureau des Longitudes (1938), and associate of the Royal Academy of Sciences at Upsala (1938). He received honorary degrees from the University of Pittsburgh (1920), and from Cambridge University, England (1925). In 1935 he was appointed officer of the (French) Légion d'Honneur. The French Acad-

emy of Sciences awarded him the Valz Medal (1926); he was Gold Medallist of the Royal Astronomical Society (1927) and first George Darwin lecturer of that society; from the Astronomical Society of the Pacific he received the Bruce Medal (1929).

There is no doubt that he was an appreciative recipient of these distinctions, but it is equally true that they did not affect his humble attitude. Always a sincere scientist, scientific interests had the first place, and his personal ambitions were relegated to the background.

One of his significant contributions to astronomy was the institution of the Neighbors' Meetings, unofficial gatherings of astronomers of the eastern part of the United States that usually occurred three times a year. Most of these meetings were held at the Yale Observa-

tory, with Schlesinger as the gracious host. The good cheer that his presence brought to these gatherings will long be remembered by all those who had the good fortune of attending many or few of them.

In 1900 he married Eva Hirsch of Ukiah, California, who died in 1928. The following year he married the former Mrs. Philip Wakeman Wilcox, of Atlanta, Georgia, and New York City. No account of his life would be complete without grateful acknowledgment of the devoted care that he received from his wife during this second marriage, and more especially during the last five years of his life when his health was failing. He is survived by his widow and a son by his first marriage, Frank Wagner Schlesinger, now of the Franklin Institute.

DIRK BROUWER

PHOTOGRAMMETRY AND AERIAL RECONNAISSANCE

PHOTOGRAMMETRY is the recently developed science and art of obtaining reliable surface measurements by means of aerial photography. Its beginning dates to 1851 when the photographic camera was first used for surveying purposes, but during the early years its application was rather limited because the surveyor was unable to find suitable heights from which to photograph the land to be surveyed. This limiting factor was entirely overcome with the advent of the aeroplane which provided means for carrying the camera aloft to record rapidly and accurately the physical and cultural features of any area on the earth's surface. Ordinary aerial photographs possess a wealth of pictorial detail, of inestimable value in many branches of science and engineering, but do not possess the accuracy of form necessary for mapping. To overcome this defect has been the task of the photogrammetrist.

The rapidly expanding activities of the Army Air Forces on a world-wide basis created an urgent need for some quick method of charting large areas of

the earth's surface which were either inadequately mapped or not mapped at all. To meet this need a photogrammetric system was developed in 1941 and is being used today for the production of aeronautical charts.

One plane, flying down planned courses spaced twenty-five miles apart, can photograph an area the size of the United States in 500 hours of actual flying time, and the photographs can be converted into small-scale maps in fifteen months by a force of 200 people. The approximate labor cost of compiling the reconnaissance maps from the aerial photographs would be about one-half million dollars.

These amazing figures are based on actual production by the Geological Survey during the past two years in making aeronautical charts for the Army Air Forces by a new system of aerial photographic mapping utilizing oblique photographs. The method, developed by the Geological Survey and Army Air Forces, is commonly called the trimetrogon system because three cameras containing



AN "OBLIQUE" FROM TRIMETROGON PHOTOGRAPHY BY ARMY AIR FORCES

wide angle metrogon lenses of six-inch focal length are used for taking the aerial photographs.

An area of over 3,000,000 square miles of the earth's surface has been mapped to date in the Geological Survey by this system. To illustrate the speed attainable with this method, a map covering 89,000 square miles of Africa (approximately the size of Great Britain) was made ready for use within one week after the films were received in the United States.

The Army uses various types of aircraft for photographic work. Three cameras are mounted in each aircraft; the central camera points vertically

downward and takes a photograph, commonly called a vertical, of the area directly beneath the plane; the two other cameras point obliquely downward to the right and left of the aircraft and take photographs, called obliques, covering the remaining area from horizon to horizon. In flight the operation of the three cameras is controlled by an intervalometer which regulates the simultaneous exposure of all three.

The basic principles of surveying used in this type of mapping from aerial photographs are similar to those used in plane-table triangulation, in which horizontal or ground directions to common images from several stations serve to

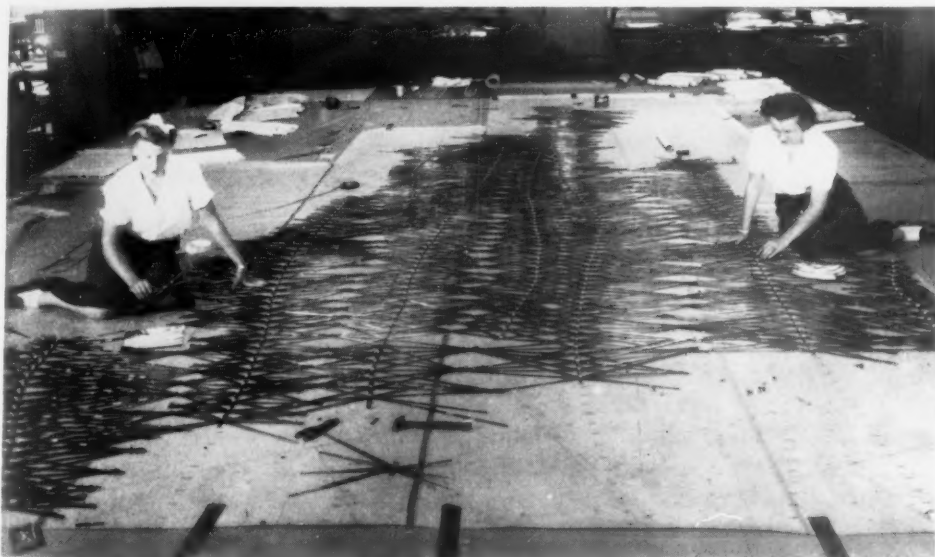
locate their positions which then are used as a guide in the sketching of detail features. The application of these principles of surveying to vertical photography became known as the radial line method, which has been used extensively in the past. The subsequent application of this radial line method of compilation to the trimetrogon system of photography led to the present reconnaissance system.

Each exposure of the three cameras yields three photographs covering a usable area of approximately 250 square miles. The successive photographs overlap in the line of flight, giving at least two views of all points in the entire area to be mapped. This overlap is necessary in order to obtain directions to image points from several stations, thereby establishing their horizontal positions as in the plane-table survey.

Since direction lines are necessary to establish the true positions of points on the map it is essential that these be horizontal directions, the same as those obtained with ground surveying methods. It naturally follows that, when some point on each aerial photograph is found from which all directions to points in the

surrounding area are the same on the photograph as on the ground, this point can be used to obtain the necessary horizontal direction lines. There is a point on each vertical photograph which, for all practical purposes, satisfies this condition. The vertical photograph, covering an area directly beneath the plane, contains the image of the ground point which would be at the foot of an imaginary plumb-line dropped from the plane at the time of the camera exposure. This ground point is called in photogrammetry the *ground nadir point* and its corresponding image on the photograph is called the *photograph nadir point*. There is a ground nadir point for each exposure of the three cameras throughout the flight of the aircraft and these points can be used as the origin of all direction lines for the photographic survey. To obtain these ground direction lines from the photographs, both vertical and obliques, is a fundamental operation in this type of mapping.

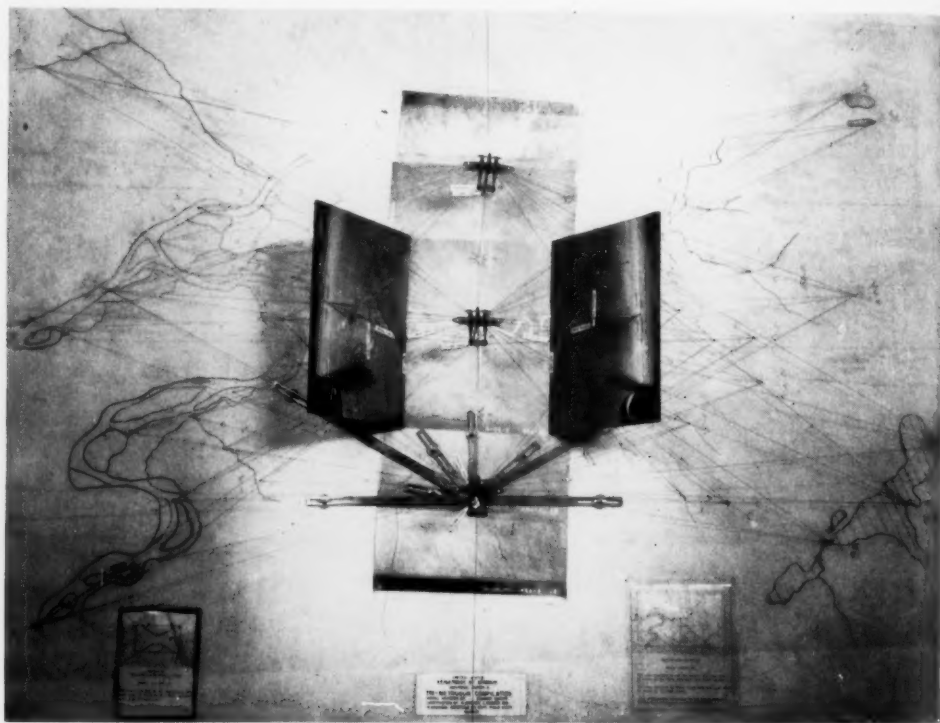
The first step in the mapping procedure is the selection and marking of images on the photographs to serve as control points for the map compilation. Included among these will be points of



METAL TEMPLATES ASSEMBLED OVER THE MAP MANUSCRIPT

known geographic positions. Before the photograph can be used further in the mapping operation the photograph nadir point must be located on the vertical photograph. To do this requires analyses of the pictures to determine the amount and direction of the cameras' tilt at the instant of each exposure. After this operation is completed, the first direction lines to be used are drawn on the vertical photographs so as to join

directions as represented in the plane of an oblique photograph onto a horizontal or ground plane. The Rectoblique Plotter, an instrument with a mechanical linkage which accomplishes this projection, was developed by the Geological Survey to be used for this operation. The ground directions to points on the left and right oblique are drawn on sheets of transparent tracing paper by means of this plotter.



MODEL ILLUSTRATING TRIMETROGON COMPILATION

successive photograph nadir points, and are called *azimuth lines*. These lines serve as base lines for the photographic survey since, on the ground, they would join successive ground nadir points and thus represent the course of the photographic flight.

The next operation involves the determination of the ground directions to the points previously selected on the oblique photographs. Since all direction lines used in the photographic survey must be horizontal, it is necessary to project the

These sheets, showing the direction lines from the ground nadir point to each selected image on the left and right oblique photograph, are called *paper templates*, one of which is made for each exposure of the cameras during the flight. The direction or azimuth lines previously established on the vertical photographs are then transferred to the paper templates, which now record all the direction lines to be used in the photographic survey.

The direction lines to images on the



THE VERTICAL SKETCHMASTER

IS USED TO TRANSFER FEATURES FROM THE VERTICAL PHOTOGRAPHS TO THE MAP MANUSCRIPT.

photographs as recorded on the paper templates can now be used to locate these particular points in their true map positions. Any particular area to be mapped is usually covered by numerous parallel flight strips spaced approximately twenty-five miles apart, and to make a map of the entire area requires the establishment of direction lines on paper templates for each flight. Metal templates are then built from the paper templates and are assembled on a sheet of cellulose acetate on which the ground control points have been plotted. The intersecting metal arms establish on this sheet the positions of the main photographic control points.

The features to be shown on the map are first outlined directly on the aerial

photographs using stereoscopes, instruments which make possible the perception of differences in elevation.

After completing the stereoscopic examination and delineation of details, the original map can be made. The outline of the features as shown on the photographs is transferred to the map manuscript by the use of a vertical and an oblique Sketchmaster. Utilizing the Camera Lucida principle, the Geological Survey developed these instruments to view the image of the photograph superimposed over the map manuscript, to match the image points marked on the photograph over their correct map position as shown on the acetate sheet, and to sketch the physical and cultural features thereon.

JAMES LEWIS

PENICILLIN, THE NEW GERM FIGHTER*

BLOOD is of the animal kingdom. Bacteria, which poison blood and destroy cells and tissues, are of the vegetable kingdom. And sulfanilamide is a coal-tar derivative of the mineral kingdom. Until very recently man's most powerful known ally against the virulent little parasitic plants was this mineral compound of sulfur. It has been made into tablets for dosing by the mouth, into a solution for injection into the circulation, into a powder for dusting on wounds, and more recently various sprays containing sulfanilamide, and ointments, films, and other plastic membranes compounded of sulfanilamide mixed with soothing oils and analgesics have been fabricated as a dressing for wounds and burns. Reports of the value of these treatments have come from many battle-fronts, base hospitals, and casualty stations, as they have been coming too from civilian hospitals. Destructive infections have been cleared up; periods of illness and wound healing have been mercifully reduced; lives have been saved. Undoubtedly the discovery of the bacteriostatic properties of this synthetic chemical is one of the great achievements of modern medicine.

And yet, sulfanilamide is not an infallible remedy. There have been tragic disappointments. There are some serious germ infestations against which it seems to be powerless, or nearly so.

For example, a massive invasion of the blood stream by staphylococci, called staphylococcal septicemia, suffers only a moderate setback from even the most massive dosing with sulfonamide drugs. Before sulfanilamide came into use the death rate from this blood poisoning was eighty-five to ninety per cent; under sulfonamide treatment it has been reduced to an average of sixty-five to seventy per cent, but that is still cruelly high. There is also a rare type of pneumonia caused by staphylococcal infection

of the lungs against which the sulfa drugs are only feeble protection, though they are usually victorious in combatting the pneumococci and streptococci of ordinary pneumonia.

Gas gangrene bacilli yield grudgingly to sulfanilamide and only in a limited degree; a severe infection, even though heavily treated, is often fatal. Staphylococcal infection of burns is also a stubborn problem, for the microbes multiply with overwhelming rapidity among the dead and dying cells of the seared flesh, and they seem to be able to develop a tolerance for the drug. After the first day or two sulfanilamide does not seem to have much effect. The British have produced a new drug, proflavin, for which many special advantages are reported. It is said to be more potent than the sulfonamides against the staphylococci. But since proflavin is toxic in the blood stream, and therefore can be used only on the outside of wounds, some surgeons will not risk it. A more recent British introduction is propamidine, another synthetic compound which also is applied only externally.

If that were all that could be said of the present medical front against sulfonamide-resistant bacteria, there would not be much point to bringing up the subject. But there are exciting new developments, powerful reinforcements already on the scene, and this time the defense comes, not from the mineral kingdom, but from the vegetable.

There is a tiny fungus, a greenish-blue scum similar in appearance to common bread mold. This fungus produces a substance, a fragile, unknown chemical compound, which is by far the most potent known agent against bacteria. Tests show that a dilution of one part in one hundred million is sufficient to prevent the growth of the highly infectious blood-destroying *Staphylococcus aureus*. The mould is known botanically as *Penicillium notatum*, and its mysterious

* Chapter from the author's forthcoming book, *Science at War*.

germ-fighting extract has accordingly been named penicillin.

A recent case in a New England hospital will illustrate its power. The wife of a university official lay at the point of death, her blood the prey of a spreading infection of *Staphylococcus aureus*. Sulfonamide compounds had been used from the first appearance of symptoms, but with little effect; the invasion was racing through her system and would be fatal when the multiplication of bacteria reached the critical stage. The attending physician had heard of penicillin. Though not yet on the market it has been produced in a few laboratories for experimental and clinical testing, and as a last resort the doctor appealed for a dose for his dying patient. The penicillin was rushed to him by airplane, injected into the poisoned bloodstream, and thereafter the golden germs simply fell away as though mowed down by an invisible reaper. It seemed miraculous, but there are scores of equally moving rescues in the case histories of penicillin.

The discovery of this remarkable weapon against disease dates back to 1929. It was purely accidental. Dr. Alexander Fleming, in St. Mary's Hospital, London, was growing colonies of bacteria on glass plates for certain bacteriological researches. One morning he noticed that a spot of mold had germinated on one of the plates. Such contaminations are not unusual, but for some reason, instead of discarding the impurity and starting fresh, Dr. Fleming decided to allow it to remain. He continued to culture the plate, and soon an interesting drama unfolded beneath his eyes. The area occupied by the bacteria was decreasing, that occupied by the mold was increasing, and presently the bacteria had vanished.

Dr. Fleming now took up this fungus for study on its own account. He recognized it as of the penicillium genus, and by deliberately introducing a particle into culture mediums where bacteria were growing, he found that quite a

number of species would not grow in its presence. There were other species which did not seem to be bothered. As he pursued his experiments the scientist noticed that the bacteria which were able to live with the penicillium were of the group known as gram-negative, so called because they give a negative reaction to a certain staining test named the gram-test, after its inventor. Those which were unable to endure the mold and died in its presence were gram-positive bacteria. In his laboratory, whenever he wanted to get rid of a growth of gram-positive bacteria, Fleming would implant a little penicillium, and after that the microbes disappeared.¹

There are beneficial bacteria among the gram-positive group, but it also includes some of the most predatory microbes known to human pathology. For example, the causative agents of such horrible afflictions as septicemia, osteomyelitis, gas gangrene, tetanus, anthrax, and plague are gram-positive. The streptococci, staphylococci, and pneumococci are all of this grouping. So the medical scientists began to speculate. Since the mold destroyed gram-positive organisms on a culture plate, could it be used to destroy gram-positive disease germs in the living body?

This question was the starting point of a medical research which has multiplied into many studies both in Great Britain and the United States. Fundamental to the whole program was the separation and concentration of the active substance, an achievement which was first accomplished by British investigators. The British also were first to report the treatment of human disease with penicillin. A team of biochemists and bacteriologists at Oxford has been especially active, and has reported many cures. In the United States, studies have been made at the College of Physicians and Surgeons in New York, the Mayo Clinic,

¹ Fleming later discovered that there are a few gram-negative bacteria which are vulnerable to the mold.

the National Institute of Health, the Evans Memorial Hospital of Boston, and practically all the large pharmaceutical houses. Since 1941 the development of penicillin in quantities sufficient for clinical use has been a major interest of the Committee on Medical Research, and its support of the work in several centers has undoubtedly had much to do with the progress recently made. At the same time, independent groups have contributed important findings which are part of our advance.

Recent clinical tests leave no doubt of the medical and surgical value of penicillin. It has cured acute cases of blood infection, bone infection, eye infection, has conquered severe infestations of gonorrhea, has cleared bacteria from massive burns and other wounds—and has done these jobs often after the sulfonamides had failed, and with no adverse reactions in the patient. A surgeon has reported, for example, that whereas the death rate of staphylococcal blood poisoning before sulfanilamide was eighty-five to ninety per cent, and after the introduction of sulfanilamide was reduced to sixty-five to seventy per cent, “even our limited use of penicillin has brought it down to 36 per cent.” And, he added, “with further knowledge of this new material, we think it can be reduced to 20 per cent.” Practically every complication of staphylococcal infection except one seems to yield. Endocarditis, a bacterial infestation of the delicate lining of the heart, is resistant even to penicillin.

The principal factor limiting the use of the new germ-fighter has been production. Enormous quantities of the mold have to be grown to obtain even meager supplies. Also, the product is somewhat unstable, sensitive to changes in temperature, and therefore has to be kept under refrigeration. Until we know its chemical formula and are able to synthesize it, we are wholly dependent on the fungus to produce penicillin by natural vegetative processes.

Penicillium notatum is cultivated in bottles or vats, and grows on the surface of a liquid from which it draws nutriment. As the velvety mat spreads and thickens, it releases by-products which descend and dissolve in the medium, and by processing this liquid the substance is extracted. On evaporation the residue appears as a reddish brown powder, and this is penicillin as the doctor gets it. The powder dissolves readily in water, and is administered by injection into the blood stream, though it may also be laid on a wound by spray or other means. Penicillin has been used to treat wounded soldiers and sailors hospitalized home from the battle fronts, and practically all of the present production is going into military and naval use.

In the summer of 1943 production operations were still in the pilot plant stage, although considerable progress has been made toward increasing the yield. Back in 1941 it was necessary to process one hundred litres (about 26½ gallons) of the liquid to get one gram (the 30th of an ounce) of the extract, and this extract was only about twenty-five per cent “pure” penicillin. By 1943 the strains of fungi had been so selected and cultivated for high yield, and the methods of processing so improved that one hundred litres were producing ten grams having eighty-eight per cent penicillin. The processors are confident that in time they will be able to concentrate their extract to a purity close to one hundred per cent.

Meanwhile, the number of concerns engaged in production has been increased. Even with no gain in percentage of yield, substantial increases in output may be expected from the multiplication of producing units. An interesting development is the turning of a group of Pennsylvania mushroom growers to the new industry. They are familiar with the ways of fungi and instead of mushrooms for the food market they now cultivate penicillium for the drug market.

GEORGE W. GRAY